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Bureau du surintendant des institutions financières Canada

Pension Plan for the Public Service of Canada Mortality Study

Actuarial Study No. 14

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I- Executive Summary

A. Purpose

This is the fourteenth actuarial study to be published by the Office of the Chief Actuary (OCA). Increasing longevity of the Canadian population puts pressure on the cost of defined benefit pension plans. As a result, mortality rates assumptions used to prepare actuarial valuations of pension plans are of paramount importance.

The Public Service Pension Plan (the "PSSA" or "Plan") established under the Public Service Superannuation Act provides retirement, disability and survivor pension benefits to eligible federal public employees in Canada. The statutory actuarial reports on the PSSA are prepared at least every three years pursuant to the *Public Pensions Reporting Act*. The Public Sector Insurance and Pension Programs Section of the Office of the Chief Actuary conducts mortality studies of federal public sector pension plans, including the PSSA, at least every three years in order to develop mortality assumptions used in the preparation of statutory actuarial reports. Mortality assumptions consist of two parts: the starting mortality rates developed using the actual mortality experience of the pension plan, and the assumed mortality improvement rates used to project future mortality rates.

In February 2014, the Pension Experience Subcommittee of the Research Committee of the Canadian Institute of Actuaries (the "CIA") has published a report titled "Canadian Pensioners' Mortality". This report presented mortality tables developed using Canadian pensioners' mortality experience and mortality projection scale (the "CPM-B"). Pension plan actuaries consider all available relevant information in developing mortality assumptions. Therefore, a comparison of mortality tables presented in the CIA report ("CPM tables") with the scale CPM-B and mortality tables and projection scale developed for the purpose of the Actuarial Report on the Pension Plan for the Public Service of Canada as at 31 March 2011 ("2011 PSSA Actuarial Report"), was conducted. This analysis concluded that mortality rates of the CPM tables are lower than those of the 2011 PSSA Actuarial Report.

This conclusion prompted the decision to conduct a peer review of the mortality tables of the 2011 PSSA Actuarial Report. This peer review took a form of a stand-alone mortality study prepared by the Social Insurance Program Section of the Office of the Chief Actuary.

Future improvements in mortality are included in the evaluation of the financial status of the PSSA. This study quantifies the impact of future improvements in mortality on the PSSA liability and current service cost.

B. Scope

Section II addresses results of the stand-alone mortality study for Plan year 2010. It describes data and methodology used to derive Plan's mortality rates, and presents results and comparisons with tables used for the 2011 PSSA Actuarial Report, Canada Pension Plan and CPM tables. Section III discusses assumptions on the future mortality rates of the 2011 PSSA Actuarial Report and their financial implications. Section IV presents conclusions of this study. Finally, Section V includes appendices to the study that provide detailed information on data, mortality rates, methodology, the references used for this study, and a list of contributors to this study.

C. Main findings

- The results of the peer review of the PSSA mortality tables by the Social Security Section of the OCA demonstrate that mortality assumptions for the purpose of the 2011 PSSA Actuarial Report properly use the available information and are accurate and reliable.
- The mortality rates developed under this study are somewhat lower than those used in the 2011 PSSA Actuarial Report. The differentials in period life expectancies at age 65 on the 2010 Plan year basis is 0.5 year for males (19.6 vs. 19.1) and 0.3 year for females (22.2 vs. 21.9) between the current study and the 2011 PSSA Actuarial Report. This difference is explained by the fact that the methodology used to develop the mortality rates in the 2011 PSSA Actuarial Report takes into account mortality experience for a longer historical period.
- Based on mortality rates developed under this study, a male federal public servant aged 65 in 2010 is expected to live one year longer than a Canadian male. For females, this difference is 0.6 years.
- Based on mortality rates developed under this study and the mortality rates of the CPM tables, life expectancies of federal public servants aged 65 in 2010 are similar to those of members of private sector pension plans. At the same time, members of public sector pension plans are expected to live longer than federal public servants.
- It is recommended that in developing mortality assumptions for the next PSSA statutory report more weight would be given to the recent experience.
- The tables published by the CIA are based on mortality rates that take into account pension amounts. Since PSSA database contains detailed information on members' salaries and pension amounts, it would be advisable to conduct further research in this direction.
- The liabilities and current service cost presented in the 2011 PSSA Actuarial Report are based on mortality assumptions that take into account future mortality improvements. If the future mortality improvements were not taken into account, the total actuarial liability as at 31 March 2011 of $139.9 billion presented in the 2011 PSSA Actuarial Report would be reduced by $5.2 billion or 3.7%.
- The 2012 Plan year current service cost without future mortality improvements would be $3.9 billion or 18.91% of the pensionable payroll compared to $4.1 billion or 19.76% of the pension payroll as determined under the 2011 PSSA Actuarial Report.
- From Plan years 2012 to 2050, based on the mortality assumptions of the 2011 PSSA Actuarial Report, the life expectancy of PSSA contributors and retirement pensioners at age 65 (with assumed future mortality improvements) is projected to grow from 20.8 to 22.8 years for males and from 23.1 to 24.9 years for females.
- CIA improvement scale CPM-B is comparable with the mortality improvement scale used for the purpose of the 2011 PSSA actuarial report.

II- Development of Plan Year 2010 Mortality Rates

This chapter presents PSSA mortality rates developed by the Social Security Section of the Office of the Chief Actuary (OCA). This Section has a wide experience in conducting mortality studies of the Canada Pension Plan (CPP) and the Old Age Security (OAS) Program beneficiaries.

The chapter estimates the level of mortality experienced by members of the Public Service Pension Plan (the "PSSA" or "Plan") using the same type of methodology that have been used in recent years by the OCA for the CPP and OAS Program[1]. The methodology is consistent with the one used by Statistics Canada for the development of their Life Tables for Canada and the Provinces and to the one used for the Life Tables developed by the Canadian Human Mortality Database.

The methodology used to develop the mortality rates in the 2011 PSSA Actuarial Report is based on a blend of two components which are each weighted equally by a 50% credibility factor. The first component is based on the average mortality experience of the PSSA over three Plan years 2009 to 2011 while the second component is based on the mortality assumption that was projected for Plan year 2010 in the Actuarial Report on the Pension Plan for the Public Service of Canada as at 31 March 2008 (the "2008 PSSA Actuarial Report"). The Plan year is defined as a 12-month period ending on 31 March. For example, Plan year 2010 ends on 31 March 2010.

The mortality rates derived in this chapter and resulting life expectancies are then compared with mortality rates and life expectancies obtained using the assumptions and methodology of the 2011 PSSA Actuarial Report, CPM Mortality Tables and the mortality assumption of the 25th Actuarial Report on the Canada Pension Plan as at 31 December 2009 (the "25th CPP Actuarial Report" or "CPP25").

The mortality rates in this section are derived for members of the Public Service Pension Plan aged 50 and over with a status of retired, active or deferred. The estimates are based on data covering three consecutive Plan years (2009 to 2011). As such, the resulting mortality rates are, on average, representative of the mortality experienced for Plan year 2010. For the remainder of this chapter, the group under study will be referred to as 'Plan Members'.

A. Evolution of the Number of Plan Members (1990-2010)

Table 1 shows that the increase in female members aged 50 and over has been important over the last two decades (1990 to 2010) for all three statuses (i.e., retired, active or deferred). As an example, in 1990 there were 32,500 females with a status of retired and this number has increased by 98% to 64,500 by 2010. For males, the corresponding increase over the same period has been 25% (from 84,000 to 105,000).

One of the most important increases to be noted is for females with a status of active. In 1990 there were about 19,000 females with an active status and this number has almost tripled to 52,600 in 2010, an increase of 177%. In comparison, the corresponding increase for males has only been 23% over the same period (from 38,600 to 47,400).

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[1] Office of the Superintendent of Financial Institutions, Office of the Chief Actuary (2009): *Canada Pension Plan Mortality Study, Actuarial Study No. 7.*
Office of the Superintendent of Financial Institutions, Office of the Chief Actuary (2012): *Old Age Security Program Mortality Experience, Actuarial Study No.11.*

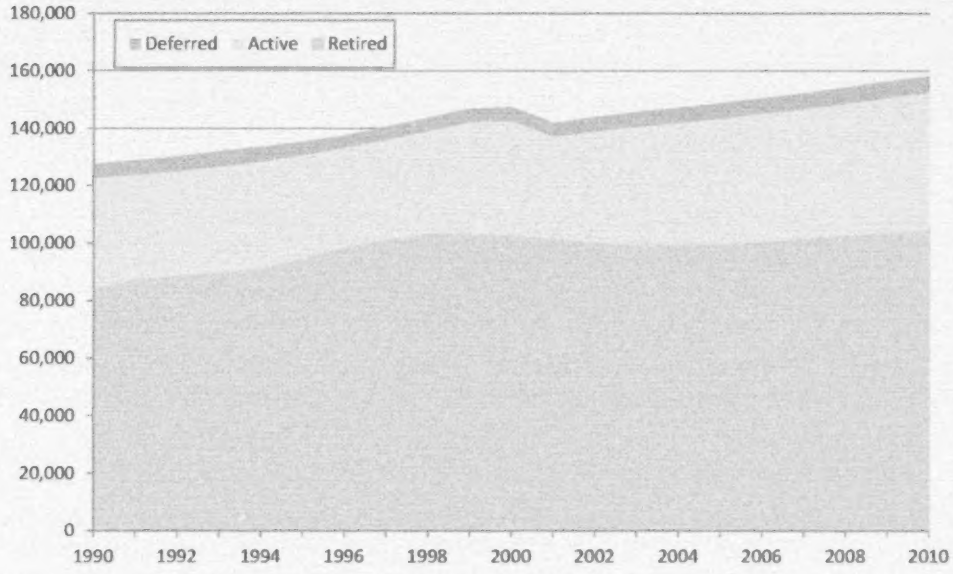
Table 1 Evolution of the Number of Plan Members Aged 50 and Over (1990-2010)

	Males			Femmes		
Status	**1990**	**2000**	**2010**	**1990**	**2000**	**2010**
Retired	84,091	102,772	104,991	32,521	47,816	64,463
Active	38,581	39,954	47,443	18,953	28,777	52,577
Deferred	4,923	4,737	5,731	1,495	2,085	4,973
Total	**127,595**	**147,463**	**158,165**	**52,969**	**78,678**	**122,013**

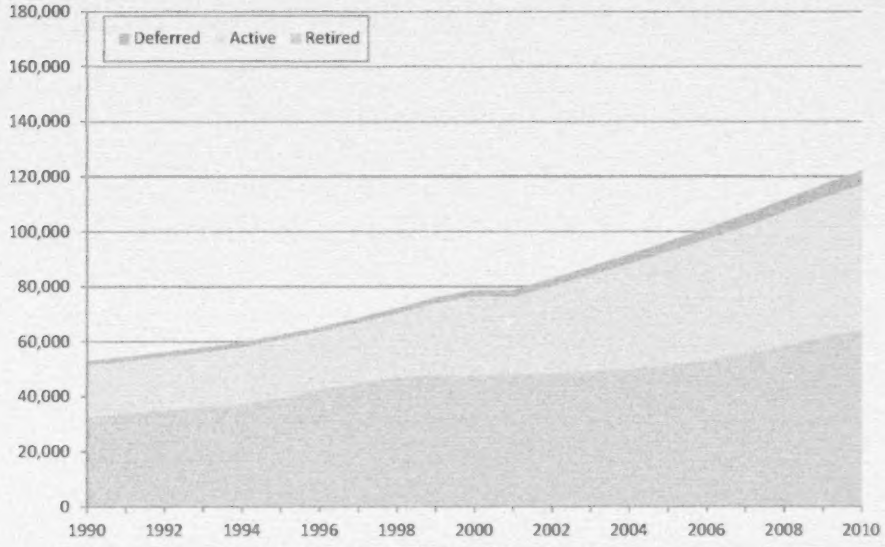
Chart 1 shows the evolution of the number of Plan Members for the period 1990 to 2010. The increase in the number of retired in the mid-1990's may be attributed to the programs that were offering early-retirement packages at that time. The increase participation of females in the PSSA plan is also reflected in this chart. Since 2007 there are more active females aged 50 and over than there are males.

Chart 1 Number of Plan Members – (1990-2010)

Males Aged 50 and Over



Females Aged 50 and Over



B. Data

The source of data for this study is a PSSA plan seriatim valuation database that was used to perform the actuarial valuation of the PSSA. The database contains plan data that covers the period from the inception of the plan to the end of Plan year 2011.

Since the current mortality study only covers the three consecutive Plan years running from 1 April 2008 to 31 March 2011, some records have been excluded for the following reasons:

- Date of termination is before the start of the study period.
- Beneficiaries with a status of either survivor or disabled over the study period.
- Inconsistent date of entry in relation to the date of termination over the study period.
- Status of inactive or unknown over the study period.
- Cash outs over the study period.

C. Methodology Overview

This section provides a general overview of the methodology used for the development of the 2010 Plan year mortality rates for Plan members who were aged 50 or older over the period running from 1 April 2008 to 31 March 2011. The methodology used to derive mortality rates in this study is similar to the one used for the OCA's CPP and OAS mortality studies and consistent with the methodology used by Statistics Canada for the development of their Life Tables for Canada and the Provinces and to the one used for the Life Tables developed by the Canadian Human Mortality Database.

The final 2010 Plan year mortality rates are derived using the following four-step process.

1. Production of Crude Mortality Rates for 2009, 2010 and 2011 Plan Years

The crude mortality rate for a given age for any given Plan year is the probability that a person at that age on 1 April of the previous year dies by 31 March of that year. Crude mortality rates are usually calculated by simply dividing the relevant number of deaths by the number of life-years that were exposed to the risk of death over that period. There exist various methods to determine crude mortality rates. For this study, annual crude mortality rates are determined using the Product-Limit Estimator (PLE) method, also known as the Kaplan-Meier Product-Limit Estimator method. This method has been used in recent mortality studies performed by the OCA on OAS and CPP beneficiaries. The results of various death and exposure tabulations are given in Appendix B. Further details of this method are provided in Appendix E.

2. Production of Crude Mortality Rates for 2010 Base Plan Year

The crude mortality rates for 2010 base Plan year are derived as a weighted average of the annual crude mortality rates observed for each of Plan years 2009, 2010 and 2011 developed in the first step. The methodology used to derive the 2010 base Plan crude rates is similar to the one used in recent mortality studies that have been done by the OCA on OAS and CPP beneficiaries.

3. Production of Graduated Mortality Rates for 2010 Base Plan Year

The crude mortality rates for 2010 base Plan year are then graduated to reflect a compromise between smoothness and fit. A Whittaker-Henderson Type B graduation method is used to produce the graduated rates up to age 100 for both genders.

4. Extension of Graduated Mortality Rates to Age 120

For this study a modified method to extend mortality rates to age 120 has been used relative to the method that was used in the recent mortality studies on OAS and CPP beneficiaries. In this study, the form which reflects that mortality at advanced ages increases at an ever slower pace was obtained by using a 3rd degree polynomial from age 97 to age 120. The resulting mortality rates at age 120 are at the same levels of 700 deaths per thousand for males and 650 deaths per thousand for females that appeared in the recent mortality studies of the OCA. The methodology used for the extension of the graduated mortality rates to age 120 is described in detail in Appendix F.

D. Mortality Experience

This study presents estimates of the level of mortality for Plan members aged 50 and over with a status of retired, active or deferred over the experience period covering three Plan years running from 1 April 2008 to 31 March 2011. The resulting mortality rates represent, on average, the mortality experienced over Plan year 2010 (i.e., from 1 April 2009 through 31 March 2010). The use of three years for the determination of mortality rates removes some of the fluctuations

that may exist in mortality from one year to the next. The use of three years is also consistent with the methodology used by Statistics Canada when developing the Life Tables for Canada and the Provinces.

1. Deaths

The first task to be done in the estimation of mortality rates is to count the number of deaths by Plan year. The age at death is determined by an exact age method. The deaths are then tabulated by Plan year, age last birthday and sex.

Table 2 presents the number and proportion of deaths for Plan Members (active, retired and deferred aged 50 and over) by age group and sex. Of the 15,712 observed deaths, there are 105 classified as centenarians (54% being females).

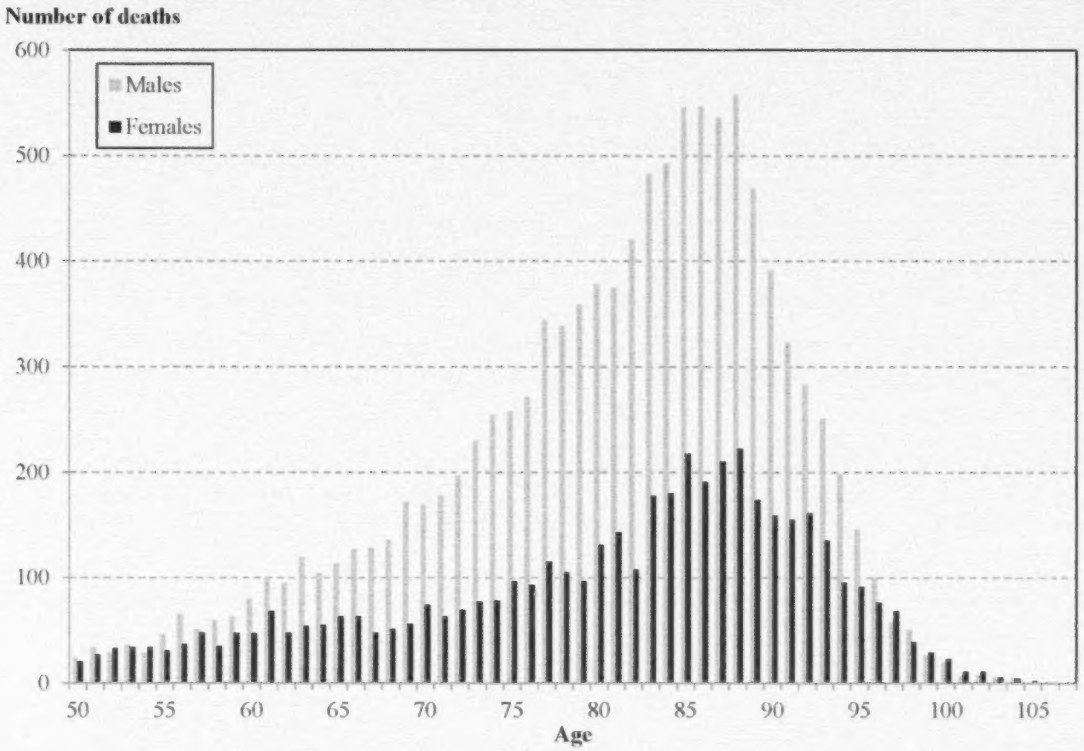
For both genders, the age at which the maximum number of deaths occurs is age 88.

Chart 2 shows the number of deaths over Plan years 2009-2011 for each sex by age.

Table 2 Deaths Aged 50 and Over (Plan Years 2009-2011)

	Retired, Active and Deferred Plan Members					
	Number of Deaths			Distribution		
Age Group	Males	Females	Both Sexes	Males	Females	Both Sexes
50-54	153	148	301	1%	3%	2%
55-59	285	198	483	3%	4%	3%
60-64	499	272	998	5%	10%	6%
65-69	677	281	958	6%	6%	6%
70-74	1,030	361	1,391	9%	8%	9%
75-79	1,573	506	2,079	14%	11%	13%
80-84	2,150	740	2,890	20%	15%	18%
85-89	2,656	1,014	3,670	24%	21%	23%
90-94	1,447	705	2,152	13%	15%	14%
95-99	382	303	685	4%	6%	4%
100+	48	57	105	0%	1%	1%
Total	**10,900**	**4,585**	**15,712**	**100%**	**100%**	**100%**

Chart 2 Deaths Aged 50 and Over – (Plan Years 2009-2011)



2. Exposures

Exposures by Plan year, age and sex are derived using a seriatim approach. Exposures are defined as the number of life-years that were exposed to the risk of death during the period examined.

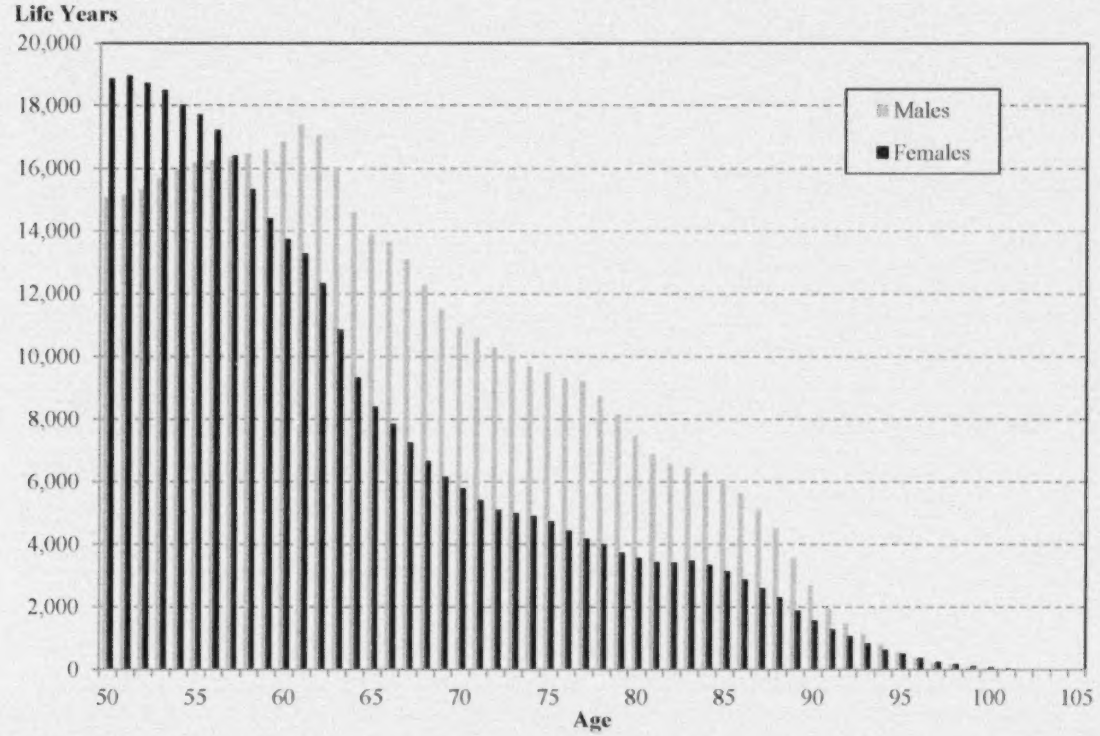
The exposures are determined by an exact age method whereby exposure for each person is measured exactly from the later of the beginning of the study period or the person becoming a Plan Member to the earlier of the time of death or the end of the study period. The exposures are then tabulated by Plan year, age last birthday and sex. Fractional years of exposures are allocated proportionally on an age last birthday basis at the end of each Plan year of the study.

Table 3 and Chart 3 highlight that the participation of females relative to males varies significantly by age group. Females have more exposures than males at ages 55 and under while males have more exposures than females at ages 55 to 95 mainly due to the past lower participation rate of females as members of the pension plan. At the advanced ages of 95 and over, females have more exposures than males because they are living longer. Deaths and exposures by individual ages for Plan years 2009 to 2011 are presented in Appendix B.

Table 3 Exposures Aged 50 and Over (Plan Years 2009-2011)

	Exposures		Distribution	
Age Group	Males	Females	Males	Females
50-54	77,199	93,078	16%	26%
55-59	81,894	81,076	17%	23%
60-64	81,917	59,526	17%	17%
65-69	64,433	36,299	14%	10%
70-74	51,543	26,207	11%	7%
75-79	44,964	21,053	10%	6%
80-84	33,682	17,239	7%	5%
85-89	24,906	12,810	5%	4%
90-94	8,077	5,412	2%	2%
95-99	1,416	1,446	0%	0%
100+	116	205	0%	0%
Total	**470,147**	**354,351**	**100%**	**100%**

Chart 3 Exposures Aged 50 and Over – (Plan Years 2009-2011)



3. Mortality Rates

a) Crude Mortality Rates for 2010 Base Plan Year

The crude mortality rates for 2010 base Plan year by age and sex are presented in Table 4.

The ratio of male to female mortality rates is an indicator of the average shorter lifetime of males compared to females. However, although males experience a higher level of mortality, the relative gap between the two sexes shows variation by age.

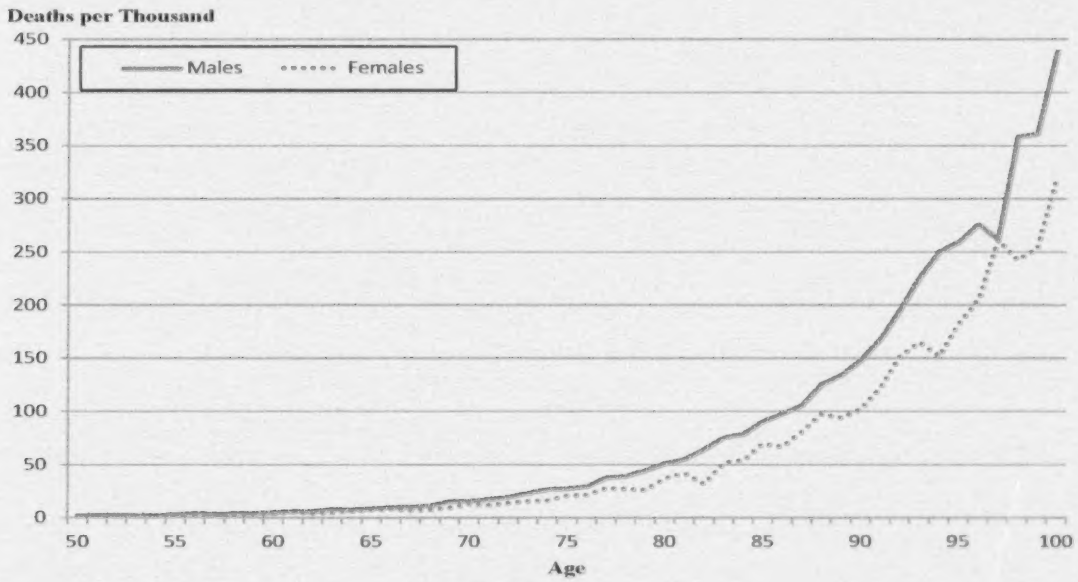
The ratio of males to females mortality rates is higher for younger and older ages: it exceeds 1.5 for ages 50-55 and is about 1.4 for ages 90-95. The lowest value of this ratio is 1.1 at age 65. The evolution pattern by age of the ratio of male to female Plan member mortality is in line with what is observed when looking at the recent CIA Canadian Pensioners' Mortality study.

The progression of the crude mortality rates for 2010 base Plan year by age and sex is displayed in Chart 4. Males experience a higher level of mortality than females at all ages while female's crude mortality rates show more fluctuations due to lower exposures.

Table 4 Crude 2010 Base Plan Year Mortality Rates (deaths per thousand)

Age	Males	Females	Ratio Males to Females
50	1.6	1.1	1.50
55	2.9	1.8	1.63
60	4.7	3.4	1.39
65	8.3	7.5	1.10
70	15.5	12.8	1.22
75	27.1	20.4	1.33
80	50.8	36.9	1.38
85	90.4	69.5	1.30
90	147.7	101.9	1.45
95	259.4	182.8	1.42

Chart 4 Crude Mortality Rates (2010 Base Plan Year)



b) Graduated and Extended Mortality Rates for 2010 Base Plan Year

The graduated and extended mortality rates by age and sex and the corresponding ratios of male to female rates are presented in Table 5.

The 2010 Base Plan Year Mortality rates by individual age and sex and other life tables for Plan members with a status of retired, active or deferred are provided in Tables 15, 17, 19 and 21 of Appendix A.

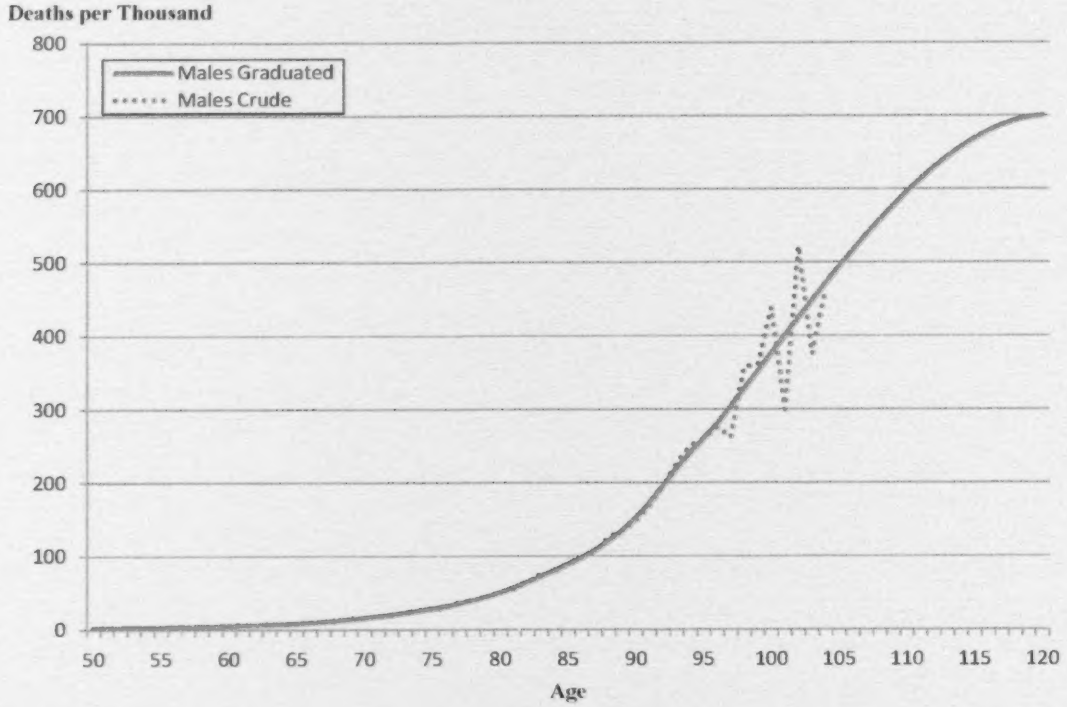
Table 5 Graduated and Extended Mortality Rates (Deaths per thousand, 2010 Base Plan Year)

Age	Males	Females	Ratio Males to Females
50	1.8	1.2	1.45
55	2.9	2.0	1.39
60	4.8	3.7	1.29
65	8.2	6.7	1.24
70	15.5	10.9	1.42
75	28.0	19.8	1.42
80	50.2	33.7	1.49
85	88.8	64.4	1.38
90	151.7	110.3	1.38
95	260.0	188.7	1.38
100	376.6	303.2	1.24
105	494.2	424.4	1.16
110	596.0	534.0	1.12
115	669.0	614.9	1.09
120	700.0	650.0	1.08

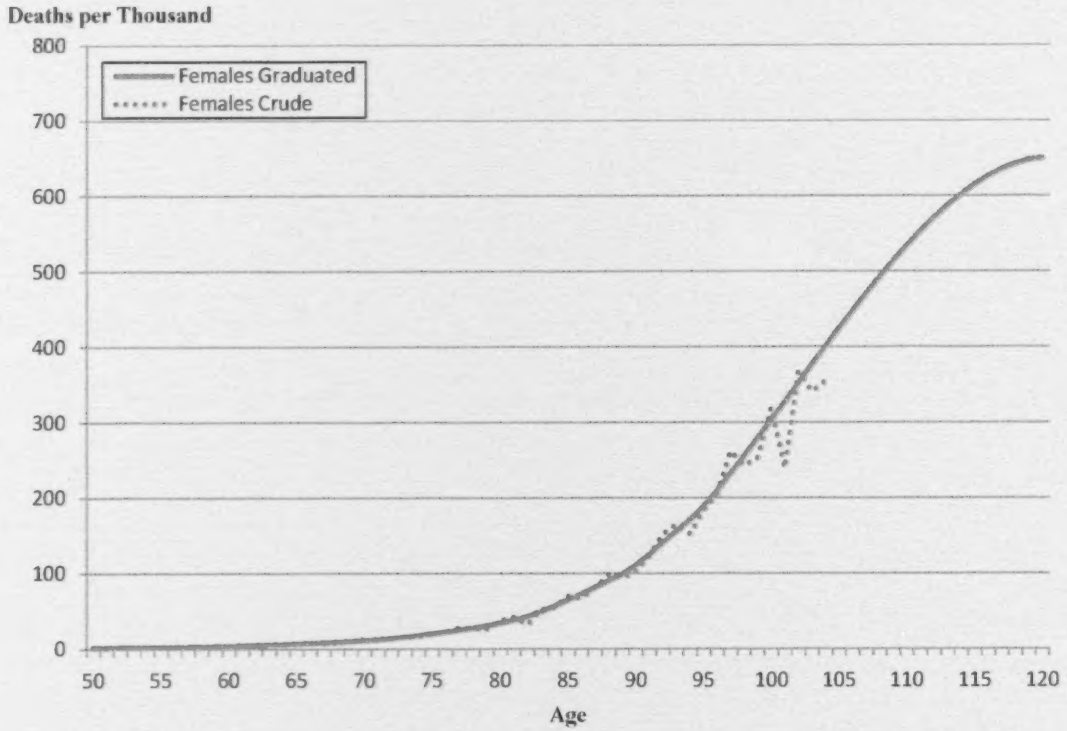
The crude and graduated mortality rates for both sexes are shown in Chart 5. The crude mortality rates are graduated up to the highest age where the standard of statistical credibility is met (97 years of age for both males and females) and then extended from that age to age 120 using a 3rd degree polynomial which reflects that mortality at advanced ages increases at an ever slowing pace.

Chart 5 Crude and Graduated Mortality Rates to Age 120 (2010 Base Plan Year)

Males



Females



E. Comparisons

In this section the current study's mortality rates are compared with those underlying the PSSA Actuarial Report as at 31 March 2011. Comparisons of life expectancies with various other segments of the Canadian population are also presented.

The methodology used to derive mortality rates in this study is consistent with the one used by Statistics Canada for the development of their Life Tables for Canada and the Provinces and to the one used for the Life Tables developed by the Canadian Human Mortality Database. As such, the resulting mortality rates are applicable to integral ages (i.e., exact or nearest age method). It is important to note that this methodology is different than the methodology used to derive the mortality rates of the 2011 PSSA Actuarial Report. In that report, the mortality rates are developed using an "Age Last Birthday" approach and the resulting mortality rates apply to the age that lies in the middle of the age range. As such, when comparing the results of this study with the 2011 PSSA Actuarial Report mortality rates the current study's mortality rates need to be converted to an "Age Last Birthday Basis". This is done by using a simple formula[2] that converts mortality rates on an exact age basis to an age last birthday basis.

1. 2011 PSSA Actuarial Report Mortality Assumption

The assumed 2010 Plan year mortality rates were derived from the assumed 2012 Plan year assumption from the 2011 PSSA Actuarial Report. The 2012 Plan year mortality rates were thus projected back to Plan year 2010 using the 25th CPP Actuarial Report mortality improvement rates assumptions by year, age and sex.

It should be reminded that the resulting 2010 Plan year mortality rates underlying the 2011 PSSA Actuarial Report are a blend of two components:

- The first component is based on the average mortality experience of the PSSA plan over the three Plan years 2009 to 2011.
- The second component corresponds to the mortality rates for Plan year 2010 as they were projected in the previous "2008 PSSA Actuarial Report".

The blended rate approach is meant to give some credibility to both the Plan's own recent experience and the previously projected mortality rates.

The 2012 and 2010 Plan years mortality rates underlying the 2011 PSSA Actuarial Report are provided in Appendix D while life table statistics are provided in Appendix A.

Table 6 shows a comparison of the current study's mortality rates and life expectancies for Plan year 2010 with those of the 2011 PSSA Actuarial Report (referred in the table as 2011 Actuarial Report).

[2] The following formula q(x) = (q[x] + p[x]* q[x+1])/(2- q[x]) was used to convert mortality rates from an exact age basis (in square bracket) to an age last birthday basis (in round bracket):

Table 6 Graduated Mortality Rates and Period Life Expectancy (Plan Year 2010)

	Mortality Rate Age Last Birthday Basis* (Per thousand, Males)			Period Life Expectancy (in years, Males)		
Age	Current Study*	2011 Actuarial Report	Ratio	Current Study*	2011 Actuarial Report	Difference
50	1.8	2.0	0.93	33.2	32.5	0.7
55	3.0	3.4	0.88	28.5	27.8	0.7
60	5.1	5.9	0.87	23.9	23.3	0.6
65	8.7	10.0	0.87	19.6	19.1	0.5
70	16.5	18.5	0.89	15.5	15.1	0.3
75	29.6	31.8	0.93	11.9	11.6	0.3
80	53.4	58.4	0.91	8.8	8.5	0.3
85	93.2	100.7	0.92	6.2	6.1	0.1
90	161.2	164.1	0.98	4.2	4.2	0.0
95	268.6	262.4	1.02	2.8	3.0	-0.2
100	385.9	347.5	1.11	2.0	2.2	-0.2
105	501.6	500.5	1.00	1.5	1.5	0.0

	Mortality Rate Age Last Birthday Basis* (Per thousand, Females)			Period Life Expectancy (in years, Females)		
Age	Current Study*	2011 Actuarial Report	Ratio	Current Study*	2011 Actuarial Report	Difference
50	1.3	1.4	0.96	36.0	35.6	0.4
55	2.2	2.3	0.92	31.2	30.9	0.3
60	4.0	4.2	0.95	26.6	26.3	0.3
65	6.9	7.3	0.95	22.2	21.9	0.3
70	11.6	12.2	0.95	18.0	17.7	0.3
75	21.0	21.3	0.99	14.1	13.9	0.2
80	35.6	38.6	0.92	10.6	10.4	0.2
85	68.3	71.8	0.95	7.6	7.5	0.1
90	117.1	121.8	0.96	5.3	5.3	0.0
95	198.0	194.5	1.02	3.6	3.7	-0.1
100	313.2	304.7	1.03	2.4	2.5	0.1
105	432.9	499.5	0.87	1.7	1.6	0.1

*The current study's mortality rates have been adjusted from an exact age basis to an age last birthday basis for comparison purposes. When reading the table all mortality rates apply to the age in the middle of the one year of age interval. For example, for age 50 the mortality rate applies to someone age 50.5 on average. Period life expectancies are calculated for exact ages.

The current study's mortality rates are generally lower than those underlying the 2011 PSSA Actuarial Report, as such, the life expectancies are higher. As an example, life expectancy at age 65 under this study is 19.6 for males and 19.1 under the 2011 PSSA Actuarial report, a differential of 0.5 year. For females, the differential is about 0.3 year (22.2 vs. 21.9). By virtue of the method used in the 2011 PSSA Actuarial Report, more weight is given to the experience which is less recent than the one used in this study. This explains the differences in mortality observed in Table 6. The reliance of the 2011 PSSA Actuarial Report on the less recent mortality experience also explains the fact that difference for males is larger than for females. Over the recent decades, mortality for males was improving at a faster pace than for females. As such, the difference between two experience components used in the 2011 PSSA Actuarial Report is larger for males than for females.

2. Current Study's 2010 Calendar Year vs. 2010 Plan Year Mortality Rates

For comparison purposes, since most published mortality tables for other segments of the Canadian population are on a calendar year basis, the current study's mortality rates were also derived on a 2010 calendar year basis. Table 7 shows a comparison between the current study's mortality rates on a 2010 calendar year and the current study's 2010 Plan year mortality rates.

For age group 65 and over, the overall ratios of 0.98 (2% improvement) for males and 0.99 (1% improvement) for females can be interpreted as an estimate of the mortality improvement rates that have occurred over the 9 months period running from the end of September 2009 (the mid-point of Plan year 2010) to the end of June 2010 (the midpoint of calendar year 2010).

Table 7 Calendar Year* and Plan Year Mortality Rates (deaths per thousand)
(Exact Age Basis)

	Males			Females		
Age	(1) Current Study CY	(2) Current Study PY	Ratio (1)/(2)	(1) Current Study CY	(2) Current Study PY	Ratio (1)/(2)
50	1.8	1.8	1.05	1.4	1.2	1.12
55	3.1	2.9	1.10	1.9	2.0	0.93
60	4.5	4.8	0.93	3.7	3.7	0.98
65	8.3	8.2	1.01	6.9	6.7	1.03
70	13.8	15.5	0.89	11.1	10.9	1.02
75	27.8	28.0	0.99	19.6	19.8	0.99
80	48.6	50.2	0.97	34.5	33.7	1.02
85	89.1	88.8	1.00	58.4	64.4	0.91
90	148.1	151.7	0.98	104.8	110.3	0.95
95	263.1	260.0	1.01	206.2	188.7	1.09
100	373.6	376.6	0.99	319.6	303.2	1.05
105	488.8	494.2	0.99	436.3	424.4	1.03
110	591.8	596.0	0.99	540.6	534.0	1.01
115	667.4	669.0	1.00	617.1	614.9	1.00
120	700.0	700.0	1.00	650.0	650.0	1.00
65+	**43.1**	**43.9**	**0.98**	**33.0**	**33.5**	**0.99**

* Since the database used for this study is only complete until 31 March 2011, the 2010 calendar mortality rates are based on only 2010 data. The results for calendar year 2010 are thus more variable and this may explain why some of the rates under the calendar year approach are higher than under the Plan year approach which uses three years of data.

3. Period Life Expectancy at Age 65 (2010 Plan and Calendar Year Basis)

In order to compare period life expectancies with other segments of the Canadian population presented in this section, the mortality rates underlying the 2011 PSSA Actuarial Report need to be adjusted from an "Age Last Birthday Basis" to an "Exact Age Basis". This is done by using a simple formula[3] that converts mortality rates on an "Age Last Birthday Basis" to an "Exact Age Basis".

[3] The following formula $q[x+1] = (q(x) + q(x+1)*p(x))/(2-q(x))$ was used to convert mortality rates from an age last birthday basis (in round bracket) to an exact age basis (in square bracket).

The life tables based on an exact age basis for this study's Plan year 2010 as well as the underlying 2011 PSSA Actuarial Report Plan years 2010 and 2012 are presented in Tables 15, 19 and 21 of Appendix A. Table 8 shows comparisons of the current study period life expectancies at age 65 with other segments of the Canadian population for Plan year and calendar year 2010.

a) On a 2010 Plan year basis two comparisons were performed:

- 2011 PSSA Actuarial Report
- 25th CPP Actuarial Report

2011 PSSA Actuarial Report

The differentials in period life expectancies at age 65 between the current study 2010 Plan year basis and the 2011 PSSA Actuarial Report 2010 Plan year basis is 0.5 year for males (19.6 vs. 19.1) and 0.3 year for females (22.2 vs. 21.9). The female and male differential for the current study 2010 Plan year is 2.6 years while it is 2.8 years for the 2011 PSSA Actuarial Report.

CPP25 (Canada) 2010 Plan Year

The CPP25 (Canada) 2010 Plan values are estimated by blending the calendar year results for years 2009 (75% weight) and 2010 (25% weight) and represent mortality for the Canadian population. The differential in period life expectancy at age 65 is 0.9 year for males (19.6 vs. 18.7) and 0.7 year for females (22.2 vs. 21.5). The female and male differential for this segment is 2.8 years.

b) On a 2010 calendar year basis four comparisons were performed:

- 2014 Private Sector Mortality Table (CPM2014Priv)[4]
- 2014 Public Sector Mortality Table (CPM2014Publ)[1]
- 2014 Mortality Table (CPM2014) - combined experience for private and public sectors[1]
- 25th CPP Actuarial Report

Private Sector calendar year 2010 - CPM2014Priv

The differentials in period life expectancies at age 65 between the current study's 2010 calendar year basis and the CPM private pension plans is 0.4 year for males (19.8 vs. 19.4) and -0.2 year for females (22.2 vs. 22.4). The female and male differential for the private pension plans of the CPM is 3.0 years.

[4] For CPM 2014 tables, the 2010 mortality rates come from the final report on Canadian Pensioners' Mortality published by the Canadian Institute of Actuaries in February 2014 (see Appendix C).

Public Sector calendar year 2010 - CPM2014Publ

This segment, which includes pension plans sponsored by governments, as well as healthcare and education sectors, experiences the lowest mortality and correspondingly highest life expectancies presented in Table 8. The differentials in period life expectancies at age 65 between the current study calendar year basis and the public pension plans of the CPM is -0.8 year for both males and females (19.8 vs. 20.6 for males and 22.2 vs. 23.0 for females). The female and male differential for the private pension plans of the CPM is 2.4 years.

Combined Private and Public Sectors calendar year 2010 – CPM2014

The differentials in period life expectancies at age 65 between the current study calendar year basis and the private and public pension plans of the CPM is -0.4 year for males (19.8 vs. 20.2) and -0.7 year for females (22.2 vs. 23.0). The female and male differential for the private and public pension plans of the CPM is 2.8 years.

CPP25 (Canada) 2010

The CPP25 (Canada) segment is the last segment that is compared in Table 8 and represents the mortality assumed in the 25th CPP Actuarial Report for the Canadian population. It is the segment which experiences the highest mortality and correspondingly the lowest life expectancies among all segments evaluated in the study. The differential in period life expectancy at age 65 is 1.0 year for males (19.8 vs. 18.8) and 0.6 year for females (22.2 vs. 21.6). The female and male differential for this segment is 2.8 years.

Table 8 Comparison of Period Life Expectancies at Age 65 – Plan and Calendar Year 2010

2010 Plan Year Basis	Males	Females	Female – Male Differential
Current Study	19.6	22.2	2.6
PSSA Actuarial Report	19.1	21.9	2.8
Differential	0.5	0.3	-
25th CPP Actuarial Report* (Canada)	18.7	21.5	2.8
Differential	0.9	0.7	-
2010 Calendar Year Basis	**Males**	**Females**	**Female – Male Differential**
Current Study	19.8	22.2	2.4
CPM Private Sector	19.4	22.4	3.0
Differential	0.4	-0.2	-
CPM Public Sector	20.6	23.0	2.4
Differential	-0.8	-0.8	-
CPM Private and Public Sectors	20.2	23.0	2.8
Differential	-0.4	-0.8	-
25th CPP Actuarial Report (Canada)	18.8	21.6	2.8
Differential	1.0	0.6	-

*The 25th CPP Actuarial Report life expectancies based on Plan year are obtained by using 75% of calendar year 2009 and 25% of calendar year 2010 values.

F. Discussion

The availability of a seriatim database of the Public Service Pension Plan members has allowed the evaluation of the mortality experience of that group using the same methodologies that have been used in recent years by the OCA to evaluate the mortality experienced by OAS program and CPP beneficiaries.

This exercise has produced somewhat lower mortality rates (higher life expectancies) than those used in the 2011 PSSA Actuarial Report. The differentials in period life expectancies at age 65 on the 2010 Plan year basis is 0.5 year for males (19.6 vs. 19.1) and 0.3 year for females (22.2 vs. 21.9) between the current study and the 2011 PSSA Actuarial Report.

This difference is explained by the fact that the methodology used to develop the mortality rates in the 2011 PSSA Actuarial Report is based on a blend of two components which are each weighted equally by a 50% credibility factor. The first component is based on the average mortality experience of the PSSA plan over the three Plan years 2009 to 2011 while the second component is based on the mortality assumption that was projected for Plan year 2010 in the 2008 PSSA Actuarial Report. At the same time the methodology used to develop mortality rates for this study is based only on the average mortality experience of the PSSA plan over the three Plan years 2009 to 2011. The reliance of the 2011 PSSA Actuarial Report on the less recent mortality experience also explains the fact that difference for males is larger than for females.

Over the recent decades, mortality for males was improving at a faster pace than for females. As such, the difference between two experience components used in the 2011 PSSA Actuarial Report is larger for males than for females.

It is recommended that in developing mortality assumption for the next PSSA statutory report more weight would be given to the recent experience.

The tables published by the CIA are based on mortality rates that take into account pension amounts. Since PSSA database contains detailed information on members' salaries and pension amounts, it would be advisable to conduct further research in this direction.

In summary, the results of the current study demonstrate that mortality assumptions developed for the purpose of the 2011 PSSA Actuarial Report properly use the available information and are accurate and reliable.

III- Projected Mortality

This section discusses the assumption on future mortality rates for PSSA contributors and retirement pensioners developed for the 2011 PSSA Actuarial Report. All information presented in this section is based on the methodology of the 2011 PSSA Actuarial Report.

A. Future Mortality Improvement Rates

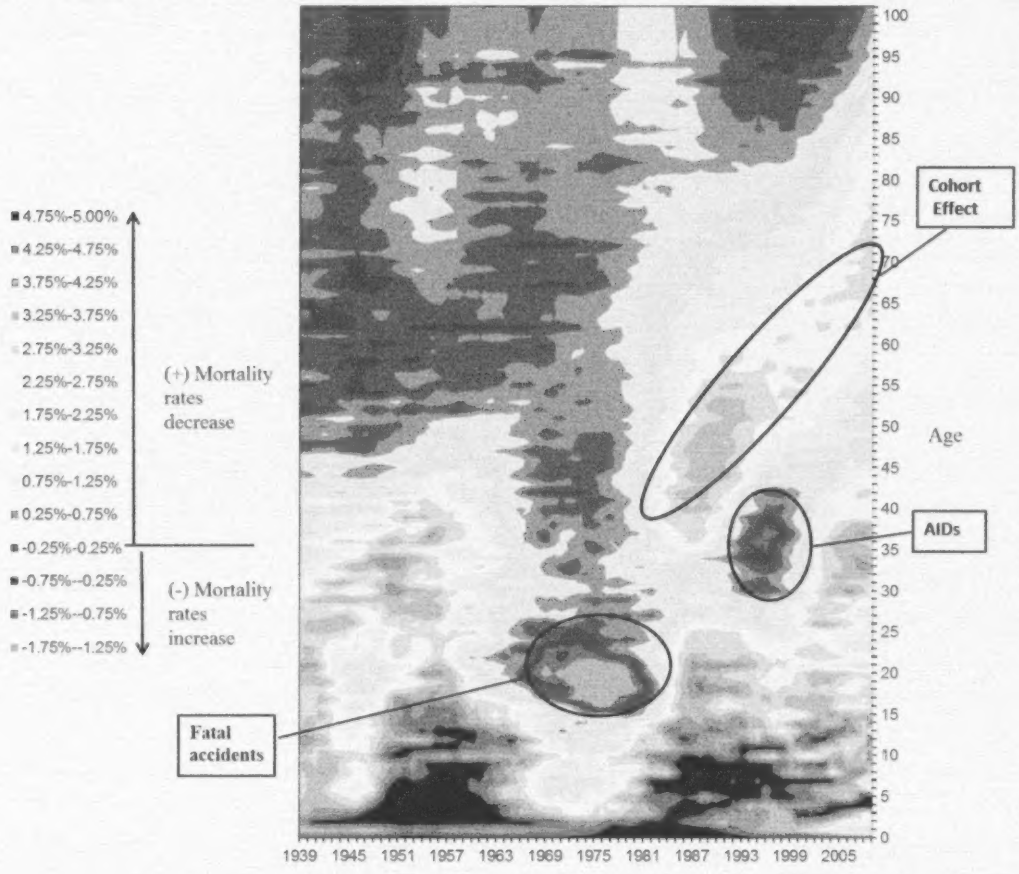
The calculations of the PSSA actuarial liability and the current service cost are based on mortality assumptions that include future improvements in mortality. That is, the methodology used to project future mortality rates involves making assumptions about future annual rates of mortality improvements by age, sex, and calendar year. These future annual rates of mortality improvements are then applied to the Plan year 2012 rates developed for the purpose of the 2011 PSSA Actuarial Report.

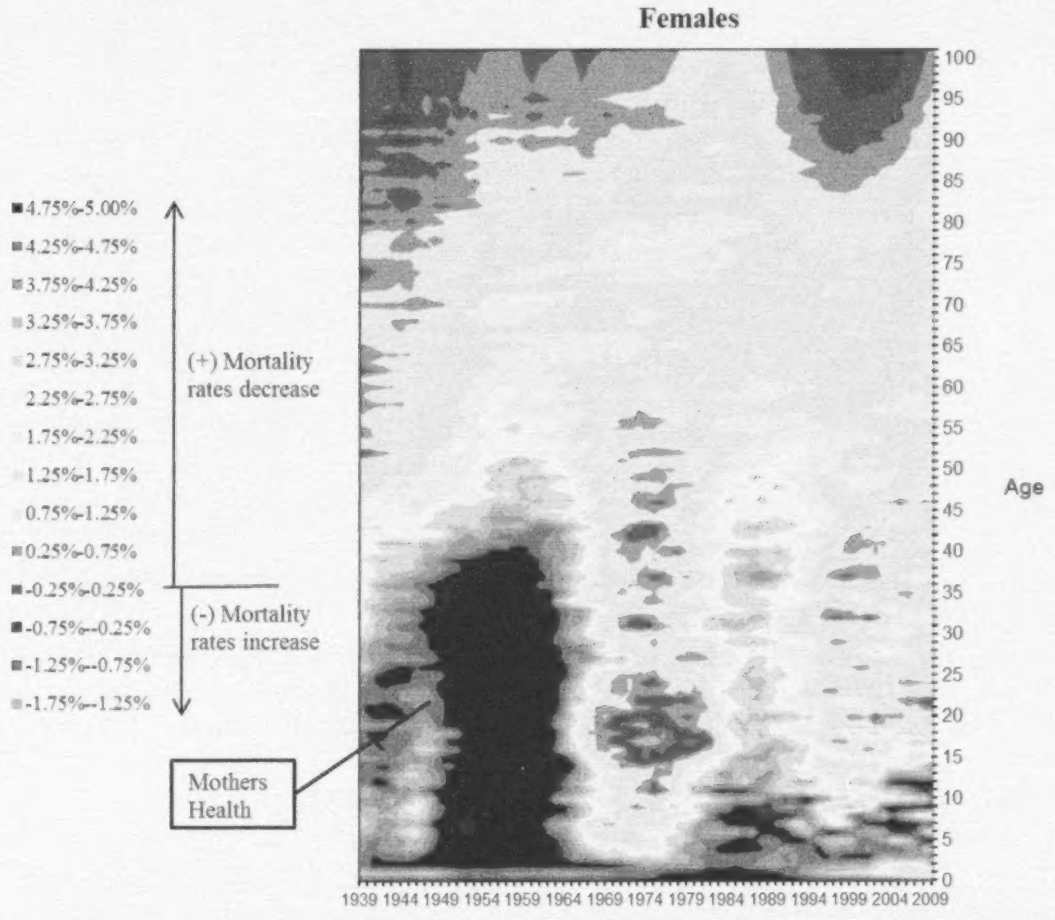
Mortality rates across all ages fell dramatically during the 20th century, leading to an unprecedented increase in life expectancy at all ages for both men and women in Canada. There have been a number of reasons for the drop in mortality rates, including access to medical care, immunizations, antibiotics, medical innovations, improvement in sanitary conditions, clean water supply, and improvements in the standard of living and education. This trend is also observed in the PSSA plan population, as supported by analysis of past mortality experience.

Heat maps of the historical Canadian mortality improvement rates (the "MIRs") are shown in Chart 6. Heat map is a useful tool to analyse the trends in mortality improvement rates. This analysis is usually performed on smoothed mortality improvement rates, 15-year smoothing in the case of Chart 6. Different colours correspond to the different levels of improvement rates. Looking at these heat maps, it can be seen, that although there has been a substantial reduction in mortality rates over time, there have been periods with low or even negative mortality improvements (i.e. little change or increase in mortality). Furthermore, these periods have been more pronounced for males than females. The most recent deterioration in mortality rates was observed in the 1990s for males aged late 20s to early 40s, which was due to increasing mortality from AIDS. Nevertheless, over the last decades, males have experienced on average higher mortality improvements than females.

In future, several factors may affect mortality improvements including new medical techniques and discoveries, the level of pollutants, air quality, improvements in nutrition, amounts of physical activity, prevalence of obesity and diabetes, emergence of new forms of diseases, prevalence of smoking, health education, etc. As such, the projections of future mortality rates are developed by first examining past mortality trends and then applying judgment as to the magnitude of the impact these trends will have on future mortality improvement rates. More analyses on the past Canadian mortality trends could be found in Actuarial Study No. 12 "Mortality Projections for Social Security Programs in Canada" published by the OCA in April 2014.

Chart 6 Historical Annual Mortality Improvement Rates (Canada)
(15-year Moving Average based on CHMD Mortality Rates)





As stated in the Revised CIA Educational Note: Selection of Mortality Assumptions for Pension Plan Actuarial Valuations published in March 2014 (the "CIA Educational Note on Mortality"): "The analysis of mortality improvement rates requires large quantities of consistent data over long periods. As a result, most mortality improvement studies are based on data gathered through social security programs and assumptions for future mortality improvements are normally based on these published mortality studies." Accordingly, the assumption on the future annual rates of mortality improvements of the 2011 PSSA Actuarial Report is based on the corresponding assumption developed for the purpose of the 25th CPP Actuarial Report. The CPP MIRs are developed on calendar year basis, so these rates have been interpolated to obtain Plan year mortality improvement rates.

MIRs for plan year 2012 are assumed to be those experienced in Canada on average over the 15-year period from 1991 to 2006. After plan year 2012, the improvement rates are assumed to reduce gradually to their ultimate level by plan year 2031. A sample of assumed mortality improvement rates is shown in Table 9.

Table 9 Sample of Improved Mortality Rates by Plan Year (applicable at the end of the plan year)

	Initial and Ultimate Plan Year Mortality Reductions (%)			
	Male		Female	
Age[5]	2012	2031+	2012	2031+
30	2.77	0.80	1.55	0.80
40	2.11	0.80	1.32	0.80
50	1.83	0.80	1.26	0.80
60	2.30	0.80	1.37	0.80
70	2.49	0.80	1.46	0.80
80	2.01	0.70	1.45	0.70
90	1.15	0.44	0.68	0.44
100	0.35	0.30	0.11	0.30
110+	0.02	0.30	0.02	0.30

The resulting mortality rates for PSSA contributors and retirement pensioners developed for the purpose of the 2011 PSSA Actuarial Report are shown in Table 10. These rates are for the Plan year and on the age at the last birthday basis.

Table 10 Sample of Assumed Mortality Rates by Plan Year for PSSA Contributors and Retirement Beneficiaries (per 1,000 individuals)

	Males			Females		
Age[5]	2012	2025	2050	2012	2025	2050
20	0.29	0.23	0.18	0.16	0.14	0.12
30	0.45	0.34	0.27	0.28	0.24	0.19
40	0.74	0.59	0.48	0.44	0.38	0.31
50	1.91	1.57	1.27	1.33	1.15	0.94
60	5.61	4.42	3.56	4.10	3.51	2.85
65	9.46	7.29	5.86	7.12	6.06	4.92
70	17.52	13.56	10.90	11.85	10.07	8.18
75	30.32	24.05	19.66	20.63	17.58	14.49
80	56.01	45.46	37.61	37.41	31.94	26.58
85	97.32	82.16	70.26	70.07	61.69	53.02
90	160.15	141.93	126.17	120.06	110.94	99.11
100	345.05	330.46	306.40	304.14	297.38	276.41

[5] Expressed in completed years calculated at the beginning of the plan year.

B. Life Expectancies

Life expectancies are the result of the assumption on future mortality rates. Table 11 shows projected life expectancies (without future improvements, a.k.a. period life expectancies) for PSSA contributors and retirement pensioners at various ages for the specified Plan years, based on each given Plan year's mortality rates. On a national level, life expectancies calculated in similar ways are usually presented by statistical agencies. Table 12 is similar to Table 11, the only difference being that it takes into account the assumed mortality improvements after the specified Plan years (with future improvements, a.k.a. cohort life expectancies). Given the continuing trend in increased longevity, it may be argued that Table 12 is more realistic than Table 11, especially for the older ages. At the same time, the extended length of the projection period increases the uncertainty of the results presented in Table 12 for younger ages.

From Plan years 2012 to 2050, life expectancy of PSSA contributors and retirement pensioners at age 65 (with assumed future mortality improvements) is projected to grow from 20.8 to 22.8 years for males and from 23.1 to 24.9 years for females, as shown in Table 12.

Table 11 Life Expectancies without Improvements after the Given Year (by Plan Year)

	Males			Females		
Age	2012	2025	2050	2012	2025	2050
20	62.0	63.9	65.5	65.2	66.4	67.8
30	52.2	54.1	55.6	55.3	56.5	57.9
40	42.4	44.3	45.8	45.5	46.7	48.1
50	32.8	34.6	36.1	35.8	37.0	38.3
60	23.7	25.3	26.6	26.5	27.6	28.8
65	19.4	20.9	22.2	22.1	23.1	24.3
70	15.4	16.8	17.9	17.9	18.8	19.9
75	11.9	13.0	14.0	14.1	14.9	15.8
80	8.8	9.7	10.5	10.6	11.3	12.0
85	6.4	7.0	7.6	7.8	8.2	8.8
90	4.6	4.9	5.3	5.6	5.9	6.2
100	2.6	2.7	2.8	2.8	2.8	3.0

Table 12 Life Expectancies with Improvements after the Given Year (by Plan Year)

	Males			Females		
Age	2012	2025	2050	2012	2025	2050
20	66.3	67.0	68.4	68.7	69.4	70.7
30	55.9	56.6	58.0	58.3	59.0	60.3
40	45.5	46.3	47.6	47.9	48.6	49.9
50	35.3	36.1	37.4	37.7	38.4	39.6
60	25.4	26.3	27.5	27.8	28.5	29.7
65	20.8	21.6	22.8	23.1	23.8	24.9
70	16.4	17.3	18.4	18.7	19.4	20.4
75	12.6	13.3	14.3	14.6	15.2	16.1
80	9.2	9.9	10.6	10.9	11.5	12.2
85	6.6	7.1	7.6	7.9	8.3	8.9
90	4.7	5.0	5.3	5.7	5.9	6.3
100	2.6	2.7	2.9	2.8	2.9	3.0

Chart 7 compares for the Plan year 2012 the impact of including future mortality improvement rates in the calculation of life expectancies for the PSSA, the 25th CPP Actuarial Report, the 26th Actuarial Report on the Canada Pension Plan as at 31 December 2012 (the 26th CPP Actuarial Report or CPP26), and CPM tables with the scale CPM-B. The 25th and 26th CPP Actuarial Report as well as CPM life expectancies based on Plan year are obtained by using 75% of calendar year 2011 and 25% of calendar year 2012 values.

The solid part of the bars in Chart 7 represents the period life expectancy, and the shaded part corresponds to the projected increase in life expectancy due to the future mortality improvements. As was discussed in Section II of this study, period life expectancies for the general population as determined for the purpose of the Canada Pension Plan actuarial reports are lower than those under the PSSA. At the same time, the CPM tables produce higher life expectancies than those of the PSSA contributors and retirement beneficiaries.

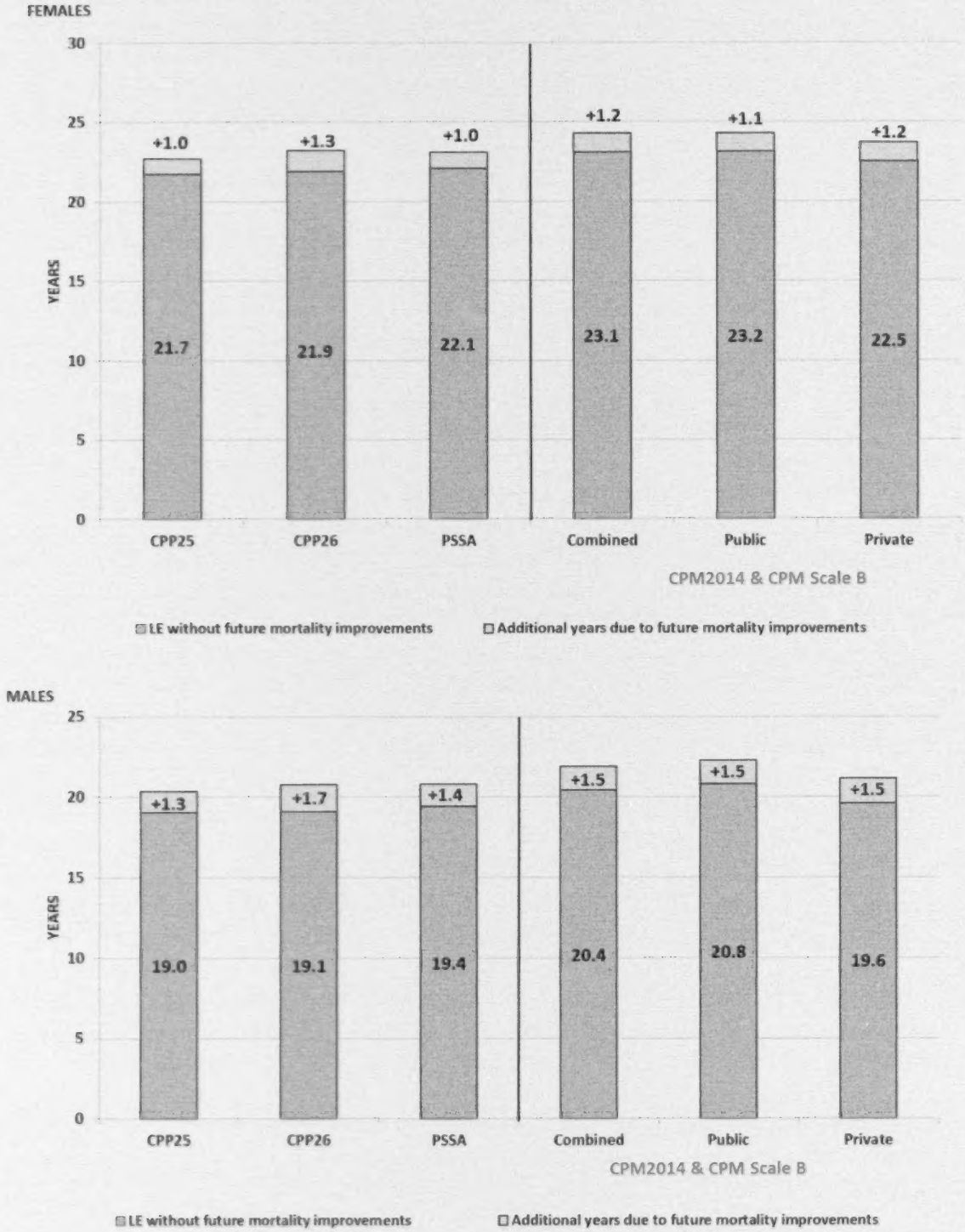
For the PSSA, the assumed future improvements in mortality increase the life expectancy in 2012 by 1.4 years for males and 1 year for females. These increases are similar to those expected under the 25th CPP Actuarial Report.

The changes made between the 25th and 26th CPP Actuarial Reports provide indications on how the PSSA mortality assumptions could evolve in the future. Firstly, the period life expectancies (without future mortality improvements) for the Plan year 2012 have increased for both males and females between the CPP25 and CPP26. This increase in mainly related to stronger actual mortality improvements between the two reports compared to the CPP25 assumption. Secondly, the strengthening of the assumption on the future mortality improvement rates for the purpose of the 26th CPP Actuarial Report results in a higher expected differential between period and cohort life expectancies for the CPP26 compared to CPP25 (1.7 years versus 1.3 years for males, and 1.3 years versus 1.0 year for females). It could be expected that similar trends will be considered for the next PSSA triennial actuarial report.

The scale CPM-B was published by the CIA at the same time as the CPM tables. This scale adopts the assumption used for the purpose of the 26th CPP Actuarial Report with respect to the ultimate improvement rates and the period of transition from higher short-term improvement rates to the ultimate rates of improvement. The CIA Educational Note on Mortality states that: "The use of the CPM-B for future mortality improvement rates would typically be an appropriate assumption in the absence of credible information to the contrary…"

As it could be seen from Chart 7, improvement scale CPM-B produces increases in life expectancy (1.5 years for males and about 1.1 years for females) that are comparable to those obtained under the assumptions of the 2011 PSSA Actuarial Report and the 26th CPP Actuarial Report. It further confirms that mortality improvement rates assumptions developed for the purpose of the 2011 PSSA Actuarial Report are reasonable.

Chart 7 Life Expectancy at Age 65 without and with Future Mortality Improvements, Plan Year 2012

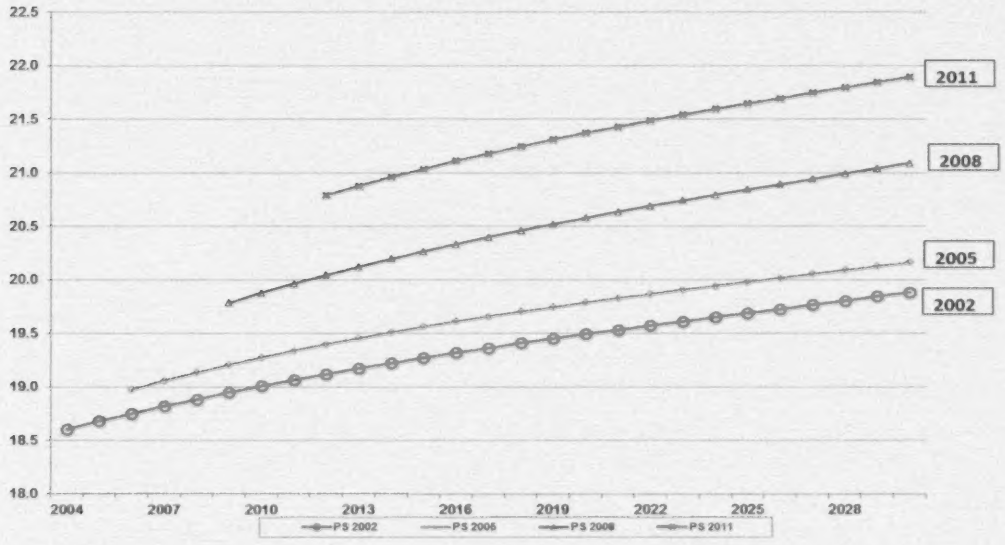


C. Impact of Mortality Assumptions on PSSA Liabilities and Current Service Cost

Mortality assumptions for the PSSA Actuarial Reports are monitored and updated every time a statutory actuarial report is prepared. Both the starting mortality rates and future mortality improvement rates are examined. Charts 8 and 9 present the evolution of projected cohort life expectancies (with future improvements) of PSSA male and female contributors and retirement pensioners at age 65 over the four actuarial reports (2002 to 2011).

For males, the projected cohort life expectancy in 2012 at age 65 increased from 19.1 as based on the mortality assumptions of the Actuarial Report on the Pension Plan for the Public Service of Canada as at 31 March 2002 (the "2002 PSSA Actuarial Report") to 20.8 as based on the mortality assumptions of the 2011 PSSA Actuarial Report. More than half of this increase of 1.7 years could be explained by the lower 2012 mortality rates used in the 2011 PSSA Actuarial Report than those projected under the 2002 PSSA Actuarial Report (the 2012 period life expectancies shown in Chart 10 are 18.4 and 19.4 years as per 2002 and 2011 PSSA Actuarial Reports). The second half of the increase is the result of higher assumed future MIRs under the 2011 PSSA Actuarial Report. Chart 10 shows that the impact of MIRs on the life expectancy at age 65 is 0.7 year under the 2002 PSSA Actuarial Report and 1.4 years under the 2011 PSSA Actuarial Report. It should be noted that the difference in projected cohort life expectancies under these two reports widens over time and reaches 2 years by 2030.

Chart 8 Life Expectancy of Public Service Male at age 65 by Plan Year (with future mortality improvements)



Over the same period, the projected female cohort life expectancy in 2012 at age 65 increased by 0.6 year from 22.5 to 23.1. The higher increase for males is related in large extent to remarkable gains made by Canadian males over the last decades. It is interesting to note that at the time of the preparation of the Actuarial Report on the Pension Plan for the Public Service of Canada as at 31 March 2005, the experience for females showed deterioration in mortality. However, as it could be seen from Chart 9, this trend has quickly reversed.

Chart 9 Life Expectancy of Public Service Female at age 65 by Plan Year (with future mortality improvements)

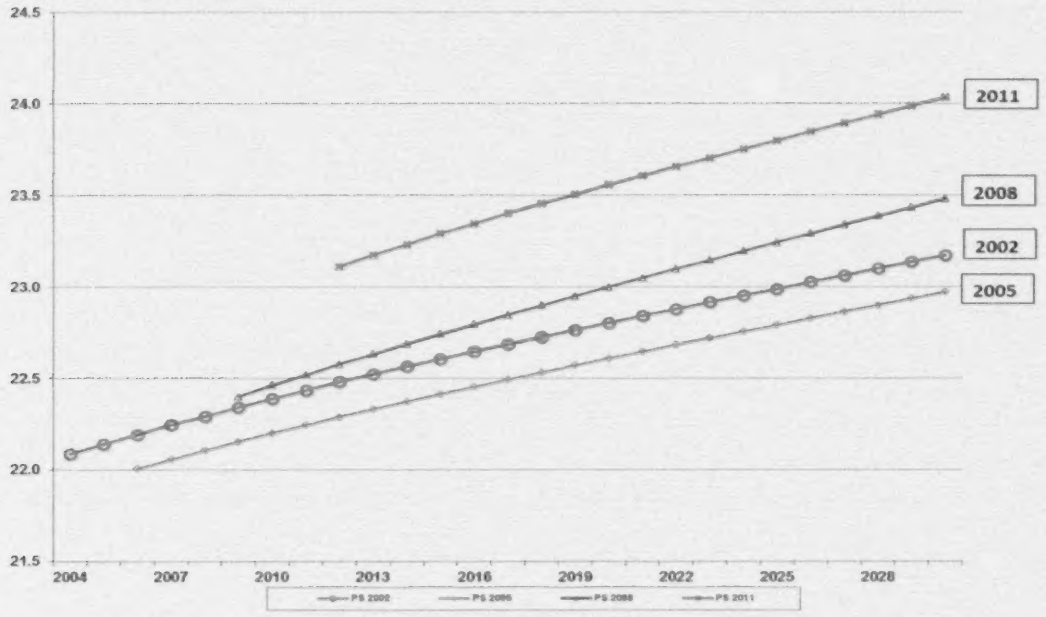
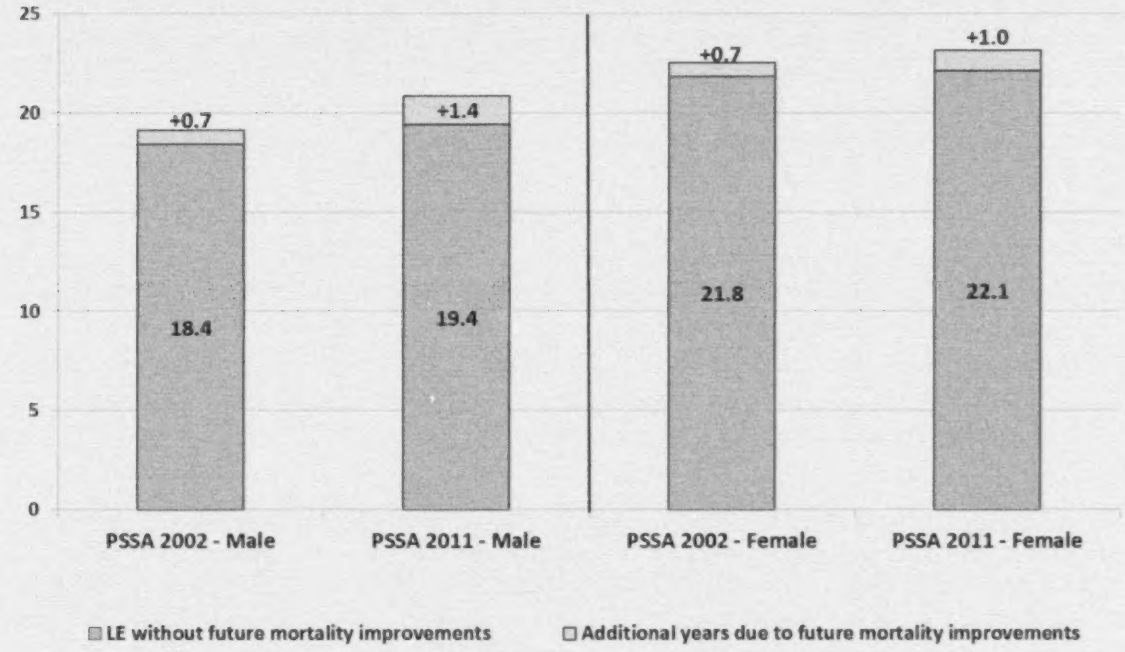


Chart 10 Life expectancy at Age 65 without and with Future Mortality Improvements - 2002 and 2011 PSSA Actuarial Reports, Plan Year 2012



The revision of mortality assumptions could have a sizable impact on Plan's actuarial liability and current service cost. Table 13 shows the impact of changes in mortality assumptions between 2002 and 2011 PSSA Actuarial Reports on the liabilities as at 31 March 2011. The total actuarial liability presented in the 2011 PSSA Actuarial Report is $139.9 billion. If instead, the mortality assumptions of the 2002 PSSA Actuarial Report were used, the total liability would decrease by $4.6 billion or 3.3% on 31 March 2011. The 2012 current service cost determined using 2002 mortality assumption would be $4.0 billion or 19.20% of the pensionable payroll compared to $4.1 billion or 19.76% of the pension payroll as determined under the 2011 PSSA Actuarial Report.

Table 13 Liabilities as at 31 March 2011 under Mortality Assumptions of the 2002 and 2011 PSSA Actuarial Reports

	PSSA liabilities[6] ($ millions)		
Description	**Superannuation Account**	**Pension Fund**	**Total**
With mortality assumptions of the 2011 PSSA Actuarial Report	93,057	46,849	139,906
With mortality assumptions of the 2002 PSSA Actuarial Report	89,735	45,566	135,301
Difference	(3,322)	(1,283)	(4,605)
Difference %	(3.6%)	(2.7%)	(3.3%)

[6] Administrative expenses and pension modernisation cost are as presented in the 2011 PSSA Actuarial Report.

As discussed, the results of the PSSA actuarial reports take into account future potential improvements in mortality. The financial impact of excluding the future mortality improvements as at 31 March 2011 is shown in Table 14. If the future mortality improvements were not taken into account, the total actuarial liability as at 31 March 2011 of $139.9 billion presented in the 2011 PSSA Actuarial Report would be reduced by $5.2 billion or 3.7%. The cost of the future mortality improvement is divided between the Pension Fund and the Superannuation Account with 65% of this cost allocated to the Account. The 2012 current service cost without future mortality improvements would be $3.9 billion or 18.91% of the pensionable payroll compared to $4.1 billion or 19.76% of the pension payroll as determined under the 2011 PSSA Actuarial Report. By 31 March 2013, the cost of including the future mortality improvement is projected to be $3.1 billion for the Account and $2.1 billion for the Fund, for a total of $5.2 billion or 3.3% of the total liability.

Chapter 1 of the Spring 2014 Report of the Auditor General of Canada states that the actuarial liabilities of the three major public sector pension plans (the PSSA, Canadian Forces and Royal Canadian Mounted Police) include the cost of future mortality improvements. The Auditor General report further specifies that if the future mortality improvements were excluded from the calculations, the total liability for the three plans as at 31 March 2013 would be $7.7 billion lower than the total liability presented in the statutory actuarial reports. The figure of $5.2 billion discussed in the previous paragraph is included in the $7.7 billion hypothetical reduction in liabilities quoted by the Auditor General report.

Table 14 PSSA Liabilities as at 31 March 2011 with and without Mortality Improvements

	PSSA liabilities[7] ($ millions)		
Description	**Superannuation Account**	**Pension Fund**	**Total**
With mortality assumptions of the 2011 PSSA Actuarial Report	93,057	46,849	139,906
Without mortality improvements	89,688	45,064	134,752
Difference	(3,369)	(1,785)	(5,154)
Difference %	(3.6%)	(3.8%)	(3.7%)

[7] Administrative expenses and pension modernisation cost are as presented in the 2011 PSSA Actuarial Report.

IV- Conclusion

The results of the current mortality study demonstrate that mortality assumptions developed for the purpose of the 2011 PSSA Actuarial Report properly use the available information and are accurate and reliable.

The liabilities presented in the most recent Actuarial Report on the Pension Plan for the Public Service of Canada as at 31 March 2011 tabled in Parliament on 21 June 2012 include expected future mortality improvements. The cost of these future mortality improvements is $5.2 billion or 3.7% of total PSSA liabilities.

Based on today's mortality rates, federal public servants aged 65 are expected to live another 19.4 years for men and 22.1 years for women. These life expectancies are about 0.4 year higher than today's life expectancies at age 65 of the general Canadian population. By 2050, it is expected that federal public servants will live for an additional 3 years or until age 89, slightly more for women and slightly less for men.

V- Appendices

A. Complete Period Life Tables (Current Study and PSSA Report)

Table 15 Period Life Table of Members of PSSA Pension Plan (Current Study PY 2010, Exact Age Basis)

	Males				Females			
x	l_x	q_x	d_x	$\mathring{e}_x$	l_x	q_x	d_x	$\mathring{e}_x$
50	100,000	0.00176	176	33.17	100,000	0.00121	121	35.96
51	99,824	0.00192	192	32.22	99,879	0.00143	143	35.01
52	99,632	0.00211	210	31.29	99,736	0.00160	160	34.05
53	99,422	0.00232	231	30.35	99,576	0.00175	174	33.11
54	99,191	0.00258	256	29.42	99,402	0.00189	188	32.17
55	98,935	0.00285	282	28.50	99,214	0.00205	203	31.23
56	98,653	0.00315	311	27.58	99,011	0.00225	223	30.29
57	98,342	0.00347	341	26.66	98,788	0.00252	249	29.36
58	98,001	0.00384	376	25.75	98,539	0.00286	282	28.43
59	97,625	0.00429	419	24.85	98,257	0.00326	320	27.51
60	97,206	0.00482	469	23.95	97,937	0.00374	366	26.60
61	96,737	0.00542	524	23.07	97,571	0.00425	415	25.69
62	96,213	0.00606	583	22.19	97,156	0.00479	465	24.80
63	95,630	0.00673	644	21.32	96,691	0.00539	521	23.92
64	94,986	0.00743	706	20.46	96,170	0.00602	579	23.05
65	94,280	0.00822	775	19.61	95,591	0.00665	636	22.18
66	93,505	0.00919	859	18.77	94,955	0.00725	688	21.33
67	92,646	0.01040	964	17.94	94,267	0.00789	744	20.48
68	91,682	0.01189	1,090	17.12	93,523	0.00870	814	19.64
69	90,592	0.01361	1,233	16.32	92,709	0.00973	902	18.81
70	89,359	0.01549	1,384	15.54	91,807	0.01093	1,003	17.99
71	87,975	0.01757	1,546	14.78	90,804	0.01220	1,108	17.18
72	86,429	0.01988	1,718	14.04	89,696	0.01364	1,223	16.39
73	84,711	0.02240	1,898	13.31	88,473	0.01535	1,358	15.61
74	82,813	0.02508	2,077	12.60	87,115	0.01739	1,515	14.84
75	80,736	0.02797	2,258	11.91	85,600	0.01976	1,691	14.10
76	78,478	0.03129	2,456	11.24	83,909	0.02230	1,871	13.37
77	76,022	0.03515	2,672	10.59	82,038	0.02488	2,041	12.66
78	73,350	0.03946	2,894	9.96	79,997	0.02747	2,198	11.97
79	70,456	0.04441	3,129	9.35	77,799	0.03034	2,360	11.30
80	67,327	0.05019	3,379	8.76	75,439	0.03373	2,545	10.64
81	63,948	0.05688	3,637	8.19	72,894	0.03760	2,741	9.99
82	60,311	0.06443	3,886	7.66	70,153	0.04238	2,973	9.36
83	56,425	0.07242	4,086	7.15	67,180	0.04877	3,276	8.75
84	52,339	0.08046	4,211	6.67	63,904	0.05630	3,598	8.17
85	48,128	0.08885	4,276	6.21	60,306	0.06441	3,884	7.63
86	43,852	0.09789	4,293	5.77	56,422	0.07250	4,091	7.12
87	39,559	0.10822	4,281	5.34	52,331	0.08092	4,235	6.64
88	35,278	0.12035	4,246	4.93	48,096	0.08953	4,306	6.18
89	31,032	0.13449	4,173	4.53	43,790	0.09868	4,321	5.74
90	26,859	0.15169	4,074	4.16	39,469	0.11026	4,352	5.31
91	22,785	0.17248	3,930	3.81	35,117	0.12478	4,382	4.91
92	18,855	0.19574	3,691	3.50	30,735	0.14055	4,320	4.54
93	15,164	0.21909	3,322	3.23	26,415	0.15565	4,111	4.20
94	11,842	0.24049	2,848	3.00	22,304	0.17088	3,811	3.88
95	8,994	0.26002	2,339	2.79	18,493	0.18870	3,490	3.58
96	6,655	0.28013	1,864	2.59	15,003	0.20955	3,144	3.30
97	4,791	0.30404	1,457	2.41	11,859	0.23215	2,753	3.04
98	3,334	0.32817	1,094	2.24	9,106	0.25539	2,326	2.81
99	2,240	0.35241	789	2.09	6,780	0.27913	1,893	2.60
100	1,451	0.37665	547	1.95	4,887	0.30324	1,482	2.41
105	91	0.49420	45	1.45	555	0.42439	236	1.72
110	2	0.59604	1	1.15	23	0.53401	12	1.32
115	0	0.66902	0	0.98	0	0.61493	0	1.11
120	0	0.70000	0	0.80	0	0.65000	0	0.85

Table 16 Period Life Table of Members of PSSA Pension Plan (Current Study PY 2010, Age Last Birthday Basis)*

	Males				Females			
x	l_x	q_x	d_x	$\mathring{e}_x$	l_x	q_x	d_x	$\mathring{e}_x$
50	100,000	0.00184	184	32.70	100,000	0.00132	132	35.48
51	99,816	0.00201	201	31.76	99,868	0.00152	152	34.53
52	99,615	0.00222	221	30.82	99,716	0.00168	168	33.58
53	99,394	0.00245	244	29.89	99,548	0.00182	181	32.64
54	99,150	0.00271	269	28.96	99,367	0.00197	196	31.70
55	98,881	0.00300	297	28.04	99,171	0.00215	213	30.76
56	98,584	0.00331	326	27.12	98,958	0.00239	237	29.82
57	98,258	0.00365	359	26.21	98,721	0.00269	266	28.89
58	97,899	0.00406	397	25.30	98,455	0.00306	301	27.97
59	97,502	0.00455	444	24.40	98,154	0.00350	344	27.05
60	97,058	0.00512	497	23.51	97,810	0.00399	390	26.15
61	96,561	0.00574	554	22.63	97,420	0.00452	440	25.25
62	96,007	0.00639	613	21.76	96,980	0.00509	494	24.36
63	95,394	0.00708	675	20.89	96,486	0.00570	550	23.48
64	94,719	0.00782	741	20.04	95,936	0.00634	608	22.62
65	93,978	0.00871	819	19.19	95,328	0.00695	663	21.76
66	93,159	0.00980	913	18.36	94,665	0.00757	717	20.91
67	92,246	0.01114	1,028	17.54	93,948	0.00829	779	20.06
68	91,218	0.01274	1,162	16.73	93,169	0.00921	858	19.22
69	90,056	0.01455	1,310	15.94	92,311	0.01033	954	18.40
70	88,746	0.01652	1,466	15.16	91,357	0.01156	1,056	17.59
71	87,280	0.01871	1,633	14.41	90,301	0.01292	1,167	16.79
72	85,647	0.02113	1,810	13.68	89,134	0.01449	1,292	16.00
73	83,837	0.02373	1,989	12.96	87,842	0.01636	1,437	15.23
74	81,848	0.02651	2,170	12.26	86,405	0.01857	1,605	14.47
75	79,678	0.02961	2,359	11.58	84,800	0.02102	1,782	13.74
76	77,319	0.03319	2,566	10.92	83,018	0.02358	1,958	13.02
77	74,753	0.03727	2,786	10.28	81,060	0.02616	2,121	12.32
78	71,967	0.04189	3,015	9.66	78,939	0.02889	2,281	11.64
79	68,952	0.04724	3,257	9.06	76,658	0.03201	2,454	10.97
80	65,695	0.05345	3,511	8.48	74,204	0.03563	2,644	10.32
81	62,184	0.06055	3,765	7.93	71,560	0.03995	2,859	9.68
82	58,419	0.06829	3,989	7.41	68,701	0.04551	3,127	9.06
83	54,430	0.07629	4,152	6.92	65,574	0.05244	3,439	8.47
84	50,278	0.08448	4,247	6.45	62,135	0.06024	3,743	7.91
85	46,031	0.09316	4,288	6.00	58,392	0.06832	3,989	7.39
86	41,743	0.10279	4,291	5.56	54,403	0.07655	4,165	6.89
87	37,452	0.11394	4,267	5.14	50,238	0.08504	4,272	6.42
88	33,185	0.12697	4,213	4.74	45,966	0.09389	4,316	5.97
89	28,972	0.14247	4,128	4.36	41,650	0.10417	4,339	5.54
90	24,844	0.16123	4,006	4.00	37,311	0.11710	4,369	5.12
91	20,838	0.18301	3,814	3.67	32,942	0.13214	4,353	4.74
92	17,024	0.20615	3,509	3.38	28,589	0.14753	4,218	4.38
93	13,515	0.22847	3,088	3.13	24,371	0.16262	3,963	4.06
94	10,427	0.24892	2,595	2.91	20,408	0.17896	3,652	3.75
95	7,832	0.26857	2,103	2.70	16,756	0.19804	3,318	3.45
96	5,729	0.29014	1,662	2.51	13,438	0.21953	2,950	3.18
97	4,067	0.31395	1,277	2.34	10,488	0.24225	2,541	2.94
98	2,790	0.33791	943	2.18	7,947	0.26553	2,110	2.72
99	1,847	0.36194	669	2.03	5,837	0.28923	1,688	2.52
100	1,178	0.38592	455	1.91	4,149	0.31323	1,300	2.34
105	69	0.50160	35	1.42	437	0.43293	189	1.69
110	1	0.60102	1	1.14	17	0.54006	9	1.31
115	0	0.67150	0	0.98	0	0.61806	0	1.10
120	0	0.70000	0	0.80	0	0.65000	0	0.85

*When reading the table all values apply to the age in the middle of the one year of age interval. For example, for age 50 the mortality rate and life expectancy applies to someone age 50½ on average.

Table 17 Period Life Table of Members of PSSA Pension Plan (Current Study CY 2010, Exact Age Basis)

	Males				Females			
x	l_x	q_x	d_x	$\mathring{e}_x$	l_x	q_x	d_x	$\mathring{e}_x$
50	100,000	0.00185	185	33.32	100,000	0.00136	136	36.02
51	99,815	0.00211	211	32.38	99,864	0.00161	161	35.07
52	99,604	0.00237	236	31.45	99,703	0.00176	175	34.12
53	99,368	0.00263	261	30.52	99,528	0.00183	182	33.18
54	99,107	0.00289	286	29.60	99,346	0.00186	185	32.24
55	98,821	0.00313	309	28.68	99,161	0.00191	189	31.30
56	98,512	0.00333	328	27.77	98,972	0.00204	202	30.36
57	98,184	0.00351	345	26.86	98,770	0.00228	225	29.42
58	97,839	0.00371	363	25.96	98,545	0.00263	259	28.49
59	97,476	0.00402	392	25.05	98,286	0.00311	306	27.56
60	97,084	0.00447	434	24.15	97,980	0.00367	360	26.65
61	96,650	0.00509	492	23.26	97,620	0.00428	418	25.74
62	96,158	0.00584	562	22.37	97,202	0.00489	475	24.85
63	95,596	0.00666	637	21.50	96,727	0.00554	536	23.97
64	94,959	0.00746	708	20.64	96,191	0.00621	597	23.10
65	94,251	0.00827	779	19.79	95,594	0.00688	658	22.24
66	93,472	0.00913	853	18.95	94,936	0.00751	713	21.39
67	92,619	0.01010	935	18.12	94,223	0.00815	768	20.55
68	91,684	0.01121	1,028	17.30	93,455	0.00896	837	19.72
69	90,656	0.01247	1,130	16.49	92,618	0.00999	925	18.89
70	89,526	0.01385	1,240	15.70	91,693	0.01113	1,021	18.08
71	88,286	0.01556	1,374	14.91	90,672	0.01222	1,108	17.27
72	86,912	0.01783	1,550	14.14	89,564	0.01333	1,194	16.48
73	85,362	0.02075	1,771	13.39	88,370	0.01469	1,298	15.70
74	83,591	0.02418	2,021	12.66	87,072	0.01670	1,454	14.92
75	81,570	0.02780	2,268	11.96	85,618	0.01958	1,676	14.17
76	79,302	0.03152	2,500	11.29	83,942	0.02307	1,937	13.44
77	76,802	0.03522	2,705	10.64	82,005	0.02659	2,181	12.75
78	74,097	0.03896	2,887	10.01	79,824	0.02966	2,368	12.08
79	71,210	0.04327	3,081	9.39	77,456	0.03222	2,496	11.44
80	68,129	0.04862	3,312	8.80	74,960	0.03454	2,589	10.80
81	64,817	0.05583	3,619	8.22	72,371	0.03699	2,677	10.17
82	61,198	0.06464	3,956	7.68	69,694	0.04002	2,789	9.54
83	57,242	0.07349	4,207	7.17	66,905	0.04476	2,995	8.92
84	53,035	0.08147	4,321	6.70	63,910	0.05105	3,263	8.31
85	48,714	0.08913	4,342	6.25	60,647	0.05838	3,541	7.73
86	44,372	0.09720	4,313	5.81	57,106	0.06624	3,783	7.18
87	40,059	0.10657	4,269	5.39	53,323	0.07412	3,952	6.65
88	35,790	0.11865	4,246	4.97	49,371	0.08187	4,042	6.15
89	31,544	0.13256	4,181	4.57	45,329	0.09086	4,119	5.65
90	27,363	0.14815	4,054	4.19	41,210	0.10477	4,318	5.16
91	23,309	0.16799	3,916	3.84	36,892	0.12460	4,597	4.71
92	19,393	0.19183	3,720	3.51	32,295	0.14613	4,719	4.31
93	15,673	0.21762	3,411	3.22	27,576	0.16518	4,555	3.96
94	12,262	0.24209	2,969	2.98	23,021	0.18523	4,264	3.64
95	9,293	0.26310	2,445	2.78	18,757	0.20616	3,867	3.36
96	6,848	0.28325	1,940	2.59	14,890	0.22784	3,393	3.10
97	4,908	0.30521	1,498	2.41	11,497	0.25015	2,876	2.87
98	3,410	0.32768	1,117	2.25	8,621	0.27296	2,353	2.66
99	2,293	0.35053	804	2.11	6,268	0.29615	1,856	2.47
100	1,489	0.37364	556	1.97	4,412	0.31960	1,410	2.30
105	97	0.48877	47	1.47	447	0.43628	195	1.67
110	2	0.59185	1	1.16	17	0.54062	9	1.31
115	0	0.66741	0	0.99	0	0.61705	0	1.10
120	0	0.70000	0	0.80	0	0.65000	0	0.85

Table 18 Period Life Table of Members of PSSA Pension Plan (PSSA Actuarial Report PY 2010, Age Last Birthday Basis)*

	Males				Females			
x	l_x	q_x	d_x	$\mathring{e}_x$	l_x	q_x	d_x	$\mathring{e}_x$
50	100,000	0.00198	198	32.01	100,000	0.00137	137	35.11
51	99,802	0.00206	206	31.08	99,863	0.00154	154	34.15
52	99,596	0.00216	215	30.14	99,709	0.00174	173	33.21
53	99,381	0.00237	236	29.20	99,536	0.00191	190	32.26
54	99,145	0.00282	280	28.27	99,346	0.00211	210	31.32
55	98,865	0.00342	338	27.35	99,136	0.00233	231	30.39
56	98,527	0.00385	379	26.44	98,905	0.00260	257	29.46
57	98,148	0.00407	399	25.54	98,648	0.00291	287	28.53
58	97,749	0.00436	426	24.64	98,361	0.00328	323	27.62
59	97,323	0.00499	486	23.75	98,038	0.00374	367	26.70
60	96,837	0.00589	570	22.87	97,671	0.00421	411	25.80
61	96,267	0.00667	642	22.00	97,260	0.00471	458	24.91
62	95,625	0.00738	706	21.14	96,802	0.00526	509	24.03
63	94,919	0.00828	786	20.30	96,293	0.00591	569	23.15
64	94,133	0.00917	863	19.46	95,724	0.00662	634	22.28
65	93,270	0.00998	931	18.64	95,090	0.00733	697	21.43
66	92,339	0.01106	1,021	17.82	94,393	0.00806	761	20.58
67	91,318	0.01253	1,144	17.01	93,632	0.00885	829	19.75
68	90,174	0.01440	1,299	16.22	92,803	0.00981	910	18.92
69	88,875	0.01641	1,458	15.45	91,893	0.01097	1,008	18.10
70	87,417	0.01846	1,614	14.70	90,885	0.01222	1,111	17.30
71	85,803	0.02074	1,780	13.97	89,774	0.01363	1,224	16.50
72	84,023	0.02330	1,958	13.26	88,550	0.01522	1,348	15.73
73	82,065	0.02597	2,131	12.56	87,202	0.01700	1,482	14.96
74	79,934	0.02865	2,290	11.88	85,720	0.01900	1,629	14.21
75	77,644	0.03179	2,468	11.22	84,091	0.02127	1,789	13.48
76	75,176	0.03565	2,680	10.57	82,302	0.02382	1,960	12.76
77	72,496	0.04025	2,918	9.94	80,342	0.02673	2,148	12.06
78	69,578	0.04555	3,169	9.34	78,194	0.03010	2,354	11.38
79	66,409	0.05168	3,432	8.76	75,840	0.03402	2,580	10.71
80	62,977	0.05844	3,680	8.21	73,260	0.03856	2,825	10.07
81	59,297	0.06564	3,892	7.69	70,435	0.04369	3,077	9.46
82	55,405	0.07352	4,073	7.19	67,358	0.04959	3,340	8.87
83	51,332	0.08205	4,212	6.72	64,018	0.05632	3,605	8.30
84	47,120	0.09112	4,294	6.28	60,413	0.06374	3,851	7.77
85	42,826	0.10072	4,313	5.86	56,562	0.07178	4,060	7.26
86	38,513	0.11125	4,285	5.46	52,502	0.08042	4,222	6.79
87	34,228	0.12287	4,206	5.08	48,280	0.08975	4,333	6.34
88	30,022	0.13527	4,061	4.72	43,947	0.09966	4,380	5.91
89	25,961	0.14871	3,861	4.38	39,567	0.11030	4,364	5.51
90	22,100	0.16406	3,626	4.06	35,203	0.12176	4,286	5.13
91	18,474	0.18208	3,364	3.76	30,917	0.13414	4,147	4.77
92	15,110	0.20233	3,057	3.48	26,770	0.14744	3,947	4.44
93	12,053	0.22322	2,690	3.24	22,823	0.16188	3,695	4.12
94	9,363	0.24343	2,279	3.03	19,128	0.17748	3,395	3.81
95	7,084	0.26238	1,859	2.84	15,733	0.19451	3,060	3.53
96	5,225	0.28031	1,465	2.68	12,673	0.21307	2,700	3.26
97	3,760	0.29764	1,119	2.52	9,973	0.23331	2,327	3.01
98	2,641	0.31450	831	2.38	7,646	0.25515	1,951	2.77
99	1,810	0.33111	599	2.24	5,695	0.27891	1,588	2.55
100	1,211	0.34748	421	2.11	4,107	0.30474	1,252	2.34
105	91	0.50051	46	1.50	413	0.49951	206	1.50
110	3	0.50000	2	1.47	13	0.50000	7	1.47
115	0	1.00000	0	0.50	0	1.00000	0	0.50

*When reading the table all values apply to the age in the middle of the one year of age interval.
For example, for age 50 the mortality rate and life expectancy applies to someone age 50½ on average.

Table 19 Period Life Table of Members of PSSA Pension Plan (PSSA Actuarial Report PY 2010, Exact Age Basis)

	Males				Females			
x	l_x	q_x	d_x	$\mathring{e}_x$	l_x	q_x	d_x	$\mathring{e}_x$
50	100,000	0.00191	191	32.48	100,000	0.00130	130	35.58
51	99,809	0.00202	202	31.54	99,870	0.00146	146	34.63
52	99,607	0.00211	210	30.61	99,724	0.00164	164	33.68
53	99,397	0.00227	226	29.67	99,560	0.00183	182	32.73
54	99,171	0.00259	257	28.74	99,378	0.00201	200	31.79
55	98,914	0.00312	309	27.81	99,178	0.00222	220	30.86
56	98,605	0.00364	359	26.90	98,958	0.00246	243	29.92
57	98,246	0.00396	389	25.99	98,715	0.00275	271	29.00
58	97,857	0.00421	412	25.09	98,444	0.00310	305	28.08
59	97,445	0.00467	455	24.20	98,139	0.00351	344	27.16
60	96,990	0.00544	528	23.31	97,795	0.00397	388	26.25
61	96,462	0.00628	606	22.43	97,407	0.00446	434	25.36
62	95,856	0.00702	673	21.57	96,973	0.00498	483	24.47
63	95,183	0.00783	745	20.72	96,490	0.00558	538	23.59
64	94,438	0.00872	823	19.88	95,952	0.00626	601	22.72
65	93,615	0.00957	896	19.05	95,351	0.00698	666	21.86
66	92,719	0.01051	974	18.23	94,685	0.00770	729	21.01
67	91,745	0.01179	1,082	17.42	93,956	0.00845	794	20.17
68	90,663	0.01346	1,220	16.62	93,162	0.00933	869	19.34
69	89,443	0.01540	1,377	15.84	92,293	0.01039	959	18.51
70	88,066	0.01743	1,535	15.08	91,334	0.01159	1,059	17.70
71	86,531	0.01959	1,695	14.34	90,275	0.01292	1,166	16.90
72	84,836	0.02201	1,867	13.62	89,109	0.01442	1,285	16.12
73	82,969	0.02462	2,043	12.91	87,824	0.01610	1,414	15.35
74	80,926	0.02729	2,208	12.22	86,410	0.01799	1,555	14.59
75	78,718	0.03020	2,377	11.55	84,855	0.02012	1,707	13.85
76	76,341	0.03369	2,572	10.90	83,148	0.02253	1,873	13.12
77	73,769	0.03791	2,797	10.26	81,275	0.02526	2,053	12.41
78	70,972	0.04285	3,041	9.65	79,222	0.02839	2,249	11.72
79	67,931	0.04854	3,297	9.05	76,973	0.03203	2,465	11.05
80	64,634	0.05497	3,553	8.49	74,508	0.03625	2,701	10.40
81	61,081	0.06193	3,783	7.96	71,807	0.04108	2,950	9.77
82	57,298	0.06945	3,979	7.45	68,857	0.04658	3,207	9.17
83	53,319	0.07762	4,139	6.97	65,650	0.05287	3,471	8.59
84	49,180	0.08639	4,249	6.51	62,179	0.05992	3,726	8.04
85	44,931	0.09569	4,299	6.08	58,453	0.06763	3,953	7.52
86	40,632	0.10570	4,295	5.67	54,500	0.07594	4,139	7.03
87	36,337	0.11672	4,241	5.28	50,361	0.08489	4,275	6.57
88	32,096	0.12867	4,130	4.91	46,086	0.09447	4,354	6.13
89	27,966	0.14150	3,957	4.56	41,732	0.10470	4,369	5.72
90	24,009	0.15577	3,740	4.23	37,363	0.11569	4,323	5.33
91	20,269	0.17227	3,492	3.92	33,040	0.12755	4,214	4.96
92	16,777	0.19119	3,208	3.64	28,826	0.14031	4,045	4.62
93	13,569	0.21160	2,871	3.38	24,781	0.15409	3,819	4.29
94	10,698	0.23206	2,483	3.15	20,962	0.16899	3,542	3.98
95	8,215	0.25159	2,067	2.95	17,420	0.18516	3,225	3.69
96	6,148	0.26999	1,660	2.77	14,195	0.20279	2,879	3.41
97	4,488	0.28756	1,291	2.61	11,316	0.22198	2,512	3.15
98	3,197	0.30460	974	2.46	8,804	0.24279	2,138	2.90
99	2,223	0.32126	714	2.32	6,666	0.26530	1,768	2.68
100	1,509	0.33767	510	2.19	4,898	0.28973	1,419	2.46
105	131	0.48416	63	1.53	578	0.46391	268	1.57
110	5	0.49967	2	1.48	20	0.49967	10	1.48
115	0	0.66667	0	0.83	0	0.66667	0	0.83

Table 20 Period Life Table of Members of PSSA Pension Plan (PSSA Actuarial Report PY 2012, Age Last Birthday Basis)*

	Males				Females			
x	l_x	q_x	d_x	$\mathring{e}_x$	l_x	q_x	d_x	$\mathring{e}_x$
50	100,000	0.00191	191	32.37	100,000	0.00133	133	35.32
51	99,809	0.00198	198	31.43	99,867	0.00150	150	34.36
52	99,611	0.00208	207	30.49	99,717	0.00169	169	33.42
53	99,404	0.00228	227	29.56	99,548	0.00186	185	32.47
54	99,177	0.00270	268	28.62	99,363	0.00206	205	31.53
55	98,909	0.00328	324	27.70	99,158	0.00227	225	30.60
56	98,585	0.00369	364	26.79	98,933	0.00253	250	29.66
57	98,221	0.00389	382	25.89	98,683	0.00283	279	28.74
58	97,839	0.00416	407	24.99	98,404	0.00319	314	27.82
59	97,432	0.00476	464	24.09	98,090	0.00363	356	26.90
60	96,968	0.00561	544	23.20	97,734	0.00410	401	26.00
61	96,424	0.00635	612	22.33	97,333	0.00458	446	25.11
62	95,812	0.00701	672	21.47	96,887	0.00511	495	24.22
63	95,140	0.00787	749	20.62	96,392	0.00574	553	23.34
64	94,391	0.00870	821	19.78	95,839	0.00643	616	22.47
65	93,570	0.00946	885	18.94	95,223	0.00712	678	21.61
66	92,685	0.01047	970	18.12	94,545	0.00782	739	20.77
67	91,715	0.01185	1,087	17.31	93,806	0.00858	805	19.93
68	90,628	0.01363	1,235	16.51	93,001	0.00952	885	19.09
69	89,393	0.01556	1,391	15.73	92,116	0.01064	980	18.27
70	88,002	0.01752	1,542	14.97	91,136	0.01185	1,080	17.46
71	86,460	0.01969	1,702	14.23	90,056	0.01322	1,191	16.67
72	84,758	0.02215	1,877	13.50	88,865	0.01477	1,313	15.88
73	82,881	0.02471	2,048	12.80	87,552	0.01649	1,444	15.11
74	80,833	0.02729	2,206	12.11	86,108	0.01844	1,588	14.36
75	78,627	0.03032	2,384	11.44	84,520	0.02063	1,744	13.62
76	76,243	0.03403	2,595	10.78	82,776	0.02311	1,913	12.90
77	73,648	0.03846	2,833	10.14	80,863	0.02594	2,098	12.19
78	70,815	0.04357	3,085	9.53	78,765	0.02921	2,301	11.50
79	67,730	0.04948	3,351	8.94	76,464	0.03301	2,524	10.83
80	64,379	0.05601	3,606	8.38	73,940	0.03741	2,766	10.18
81	60,773	0.06298	3,827	7.84	71,174	0.04239	3,017	9.56
82	56,946	0.07061	4,021	7.34	68,157	0.04812	3,280	8.96
83	52,925	0.07896	4,179	6.86	64,877	0.05476	3,553	8.39
84	48,746	0.08787	4,283	6.40	61,324	0.06210	3,808	7.85
85	44,463	0.09732	4,327	5.97	57,516	0.07007	4,030	7.33
86	40,136	0.10772	4,323	5.56	53,486	0.07866	4,207	6.85
87	35,813	0.11922	4,270	5.17	49,279	0.08796	4,335	6.39
88	31,543	0.13151	4,148	4.80	44,944	0.09788	4,399	5.96
89	27,395	0.14487	3,969	4.45	40,545	0.10854	4,401	5.55
90	23,426	0.16015	3,752	4.12	36,144	0.12006	4,339	5.17
91	19,674	0.17810	3,504	3.81	31,805	0.13254	4,215	4.80
92	16,170	0.19831	3,207	3.53	27,590	0.14597	4,027	4.46
93	12,963	0.21922	2,842	3.28	23,563	0.16043	3,780	4.14
94	10,121	0.23955	2,424	3.07	19,783	0.17606	3,483	3.83
95	7,697	0.25872	1,991	2.87	16,300	0.19315	3,148	3.54
96	5,706	0.27696	1,580	2.70	13,152	0.21180	2,786	3.27
97	4,126	0.29467	1,216	2.54	10,366	0.23215	2,406	3.02
98	2,910	0.31168	907	2.40	7,960	0.25413	2,023	2.78
99	2,003	0.32847	658	2.26	5,937	0.27808	1,651	2.55
100	1,345	0.34505	464	2.12	4,286	0.30414	1,304	2.34
105	102	0.49951	51	1.50	432	0.49951	216	1.50
110	4	0.50000	2	1.47	14	0.50000	7	1.47
115	0	1.00000	0	0.50	0	1.00000	0	0.50

*When reading the table all values apply to the age in the middle of the one year of age interval.
For example, for age 50 the mortality rate and life expectancy applies to someone age 50½ on average.

Table 21 Period Life Table of Members of PSSA Pension Plan (PSSA Actuarial Report PY 2012, Exact Age Basis)

	Males				Females			
x	l_x	q_x	d_x	$\mathring{e}_x$	l_x	q_x	d_x	$\mathring{e}_x$
50	100,000	0.00184	184	32.84	100,000	0.00127	127	35.80
51	99,816	0.00194	194	31.90	99,873	0.00142	142	34.84
52	99,622	0.00203	202	30.96	99,731	0.00160	160	33.89
53	99,420	0.00218	217	30.03	99,571	0.00178	177	32.94
54	99,203	0.00249	247	29.09	99,394	0.00196	195	32.00
55	98,956	0.00299	296	28.16	99,199	0.00216	214	31.06
56	98,660	0.00348	343	27.25	98,985	0.00240	238	30.13
57	98,317	0.00378	372	26.34	98,747	0.00268	265	29.20
58	97,945	0.00402	394	25.44	98,482	0.00301	296	28.28
59	97,551	0.00446	435	24.54	98,186	0.00341	335	27.36
60	97,116	0.00518	503	23.65	97,851	0.00386	378	26.45
61	96,613	0.00598	578	22.77	97,473	0.00434	423	25.55
62	96,035	0.00668	642	21.90	97,050	0.00484	470	24.66
63	95,393	0.00744	710	21.04	96,580	0.00542	523	23.78
64	94,683	0.00828	784	20.20	96,057	0.00608	584	22.91
65	93,899	0.00908	853	19.36	95,473	0.00677	646	22.05
66	93,046	0.00996	927	18.53	94,827	0.00747	708	21.19
67	92,119	0.01115	1,027	17.72	94,119	0.00820	772	20.35
68	91,092	0.01273	1,160	16.91	93,347	0.00905	845	19.51
69	89,932	0.01459	1,312	16.12	92,502	0.01008	932	18.69
70	88,620	0.01653	1,465	15.35	91,570	0.01124	1,029	17.87
71	87,155	0.01859	1,620	14.60	90,541	0.01253	1,134	17.07
72	85,535	0.02091	1,789	13.87	89,407	0.01399	1,251	16.28
73	83,746	0.02342	1,961	13.16	88,156	0.01562	1,377	15.50
74	81,785	0.02599	2,126	12.46	86,779	0.01746	1,515	14.74
75	79,659	0.02878	2,293	11.78	85,264	0.01952	1,664	13.99
76	77,366	0.03214	2,487	11.11	83,600	0.02186	1,827	13.26
77	74,879	0.03621	2,711	10.46	81,773	0.02451	2,004	12.55
78	72,168	0.04096	2,956	9.84	79,769	0.02755	2,198	11.85
79	69,212	0.04646	3,216	9.24	77,571	0.03108	2,411	11.17
80	65,996	0.05266	3,475	8.66	75,160	0.03517	2,643	10.51
81	62,521	0.05939	3,713	8.12	72,517	0.03985	2,890	9.88
82	58,808	0.06667	3,921	7.60	69,627	0.04519	3,146	9.27
83	54,887	0.07463	4,096	7.11	66,481	0.05135	3,414	8.68
84	50,791	0.08323	4,227	6.64	63,067	0.05832	3,678	8.13
85	46,564	0.09238	4,302	6.20	59,389	0.06596	3,917	7.60
86	42,262	0.10225	4,321	5.78	55,472	0.07421	4,117	7.10
87	37,941	0.11314	4,293	5.38	51,355	0.08312	4,269	6.63
88	33,648	0.12497	4,205	5.00	47,086	0.09269	4,364	6.18
89	29,443	0.13772	4,055	4.64	42,722	0.10293	4,397	5.77
90	25,388	0.15191	3,857	4.30	38,325	0.11397	4,368	5.37
91	21,531	0.16834	3,625	3.98	33,957	0.12590	4,275	5.00
92	17,906	0.18721	3,352	3.69	29,682	0.13878	4,119	4.64
93	14,554	0.20761	3,022	3.42	25,563	0.15263	3,902	4.31
94	11,532	0.22814	2,631	3.19	21,661	0.16756	3,630	4.00
95	8,901	0.24783	2,206	2.98	18,031	0.18378	3,314	3.70
96	6,695	0.26648	1,784	2.80	14,717	0.20148	2,965	3.42
97	4,911	0.28439	1,397	2.64	11,752	0.22077	2,594	3.16
98	3,514	0.30171	1,060	2.48	9,158	0.24170	2,213	2.91
99	2,454	0.31852	782	2.34	6,945	0.26436	1,836	2.68
100	1,672	0.33513	560	2.20	5,109	0.28900	1,477	2.46
105	148	0.48290	71	1.53	604	0.46391	280	1.57
110	5	0.49967	2	1.48	21	0.49967	10	1.48
115	0	0.66667	0	0.83	0	0.66667	0	0.83

B. Deaths and Exposures (Plan Years 2009 to 2011)

Table 22 Deaths and Exposures (Plan Years 2009-2011) (Age Last Birthday)

	Deaths		Exposures	
Age	Males	Females	Males	Females
50	24	20	15,080	18,873
51	34	27	15,165	18,968
52	29	33	15,342	18,732
53	37	34	15,689	18,495
54	29	34	15,924	18,010
55	46	31	16,184	17,711
56	65	37	16,257	17,222
57	51	48	16,368	16,399
58	60	35	16,483	15,335
59	63	47	16,602	14,409
60	80	47	16,859	13,743
61	100	68	17,381	13,278
62	95	48	17,058	12,330
63	120	54	16,034	10,853
64	104	55	14,585	9,321
65	114	63	13,894	8,393
66	127	63	13,653	7,844
67	128	48	13,098	7,255
68	136	51	12,285	6,650
69	172	56	11,503	6,157
70	170	74	10,948	5,791
71	178	63	10,601	5,423
72	197	69	10,283	5,109
73	230	77	10,031	4,991
74	255	78	9,680	4,893
75	258	96	9,498	4,737
76	272	93	9,327	4,439
77	345	115	9,229	4,180
78	339	105	8,777	3,962
79	359	97	8,134	3,735
80	378	131	7,470	3,559
81	375	143	6,873	3,437
82	421	108	6,580	3,425
83	483	178	6,441	3,473
84	493	180	6,317	3,346
85	546	217	6,074	3,138
86	547	191	5,648	2,885
87	536	210	5,122	2,602
88	558	222	4,505	2,304
89	469	174	3,558	1,880
90	392	159	2,698	1,577
91	323	155	1,954	1,289
92	283	161	1,480	1,075
93	251	135	1,134	834
94	198	95	812	637
95	146	91	576	514
96	100	76	376	379
97	58	68	234	265
98	51	39	150	168
99	27	29	80	120
100+	48	57	116	205
Total	**10,900**	**4,585**	**470,147**	**354,351**

C. Canadian Pensioner Mortality Rates (2010)

Table 23 Mortality Rates of Canadian Pensioner Mortality (CPM) – Males (Exact Age Basis)

	CPM Males 2010		
Age	Public	Private	Combined
50	0.00261	0.00319	0.00282
51	0.00281	0.00344	0.00303
52	0.00304	0.00373	0.00328
53	0.00331	0.00406	0.00357
54	0.00360	0.00444	0.00394
55	0.00393	0.00490	0.00436
56	0.00427	0.00544	0.00487
57	0.00464	0.00603	0.00541
58	0.00502	0.00667	0.00594
59	0.00544	0.00735	0.00646
60	0.00587	0.00804	0.00695
61	0.00633	0.00874	0.00740
62	0.00683	0.00945	0.00783
63	0.00737	0.01014	0.00832
64	0.00796	0.01085	0.00889
65	0.00861	0.01157	0.00954
66	0.00931	0.01231	0.01025
67	0.01009	0.01314	0.01109
68	0.01100	0.01416	0.01205
69	0.01202	0.01538	0.01318
70	0.01321	0.01682	0.01449
71	0.01457	0.01847	0.01600
72	0.01615	0.02040	0.01773
73	0.01796	0.02263	0.01972
74	0.02007	0.02519	0.02199
75	0.02250	0.02814	0.02458
76	0.02532	0.03151	0.02755
77	0.02860	0.03536	0.03096
78	0.03239	0.03977	0.03488
79	0.03680	0.04482	0.03941
80	0.04189	0.05055	0.04465
81	0.04743	0.05668	0.05033
82	0.05373	0.06355	0.05682
83	0.06086	0.07121	0.06417
84	0.06889	0.07971	0.07245
85	0.07791	0.08909	0.08173
86	0.08799	0.09939	0.09209
87	0.09921	0.11070	0.10360
88	0.11167	0.12311	0.11634
89	0.12546	0.13670	0.13042
90	0.14072	0.15160	0.14593
91	0.15758	0.16794	0.16298
92	0.17617	0.18589	0.18171
93	0.19670	0.20564	0.20230
94	0.21935	0.22736	0.22490
95	0.24299	0.24997	0.24835
100	0.36674	0.36846	0.36878
105	0.47950	0.47950	0.47950
110	0.58042	0.58042	0.58042
115	1.00000	1.00000	1.00000
Period Life Expectancy at 65	**20.65**	**19.35**	**20.17**

Table 24 Mortality Rates of Canadian Pensioner Mortality (CPM) – Females (Exact Age Basis)

	CPM Females 2010		
Age	Public	Private	Combined
50	0.00134	0.00149	0.00135
51	0.00147	0.00162	0.00148
52	0.00160	0.00177	0.00161
53	0.00176	0.00195	0.00177
54	0.00195	0.00215	0.00196
55	0.00217	0.00241	0.00219
56	0.00243	0.00269	0.00244
57	0.00272	0.00301	0.00273
58	0.00302	0.00335	0.00305
59	0.00336	0.00371	0.00338
60	0.00371	0.00410	0.00373
61	0.00407	0.00450	0.00410
62	0.00447	0.00495	0.00450
63	0.00493	0.00546	0.00497
64	0.00544	0.00602	0.00548
65	0.00600	0.00664	0.00604
66	0.00658	0.00729	0.00663
67	0.00721	0.00797	0.00725
68	0.00789	0.00873	0.00794
69	0.00863	0.00955	0.00869
70	0.00946	0.01047	0.00952
71	0.01038	0.01149	0.01046
72	0.01144	0.01266	0.01152
73	0.01265	0.01400	0.01274
74	0.01405	0.01555	0.01414
75	0.01568	0.01736	0.01579
76	0.01760	0.01947	0.01772
77	0.01985	0.02197	0.01998
78	0.02247	0.02488	0.02263
79	0.02555	0.02828	0.02573
80	0.02914	0.03224	0.02933
81	0.03328	0.03684	0.03351
82	0.03809	0.04215	0.03835
83	0.04360	0.04825	0.04390
84	0.04991	0.05524	0.05025
85	0.05711	0.06320	0.05750
86	0.06487	0.07134	0.06529
87	0.07360	0.08041	0.07404
88	0.08337	0.09048	0.08382
89	0.09425	0.10162	0.09472
90	0.10635	0.11391	0.10684
91	0.11967	0.12731	0.12017
92	0.13442	0.14205	0.13490
93	0.15075	0.15823	0.15123
94	0.16881	0.17599	0.16926
95	0.18879	0.19548	0.18922
100	0.31809	0.31809	0.31809
105	0.41956	0.41956	0.41956
110	0.53038	0.53038	0.53038
115	1.00000	1.00000	1.00000
Period Life Expectancy at 65	**23.02**	**22.38**	**22.98**

D. PSSA Actuarial Report Mortality Rates (Plan Years 2010 and 2012)

Table 25 PSSA Actuarial Report Mortality Rates (Plan Years 2010 and 2012) (Age Last Birthday Basis)*

	Males			Females		
Age	PSSA Report PY 2010	CPP25 Cumulative Improvement Rates 2010 to 2012	PSSA Report PY 2012	PSSA Report PY 2010	CPP25 Cumulative Improvement Rates 2010 to 2012	PSSA Report PY 2012
50	0.00198	0.96236	0.00191	0.00137	0.97441	0.00133
51	0.00206	0.96138	0.00198	0.00154	0.97417	0.00150
52	0.00216	0.96040	0.00208	0.00174	0.97391	0.00169
53	0.00237	0.95942	0.00228	0.00191	0.97368	0.00186
54	0.00282	0.95844	0.00270	0.00211	0.97342	0.00206
55	0.00342	0.95746	0.00328	0.00233	0.97318	0.00227
56	0.00385	0.95648	0.00369	0.00260	0.97293	0.00253
57	0.00407	0.95551	0.00389	0.00291	0.97269	0.00283
58	0.00436	0.95453	0.00416	0.00328	0.97243	0.00319
59	0.00499	0.95355	0.00476	0.00374	0.97220	0.00363
60	0.00589	0.95258	0.00561	0.00421	0.97194	0.00410
61	0.00667	0.95160	0.00635	0.00471	0.97170	0.00458
62	0.00738	0.95063	0.00701	0.00526	0.97145	0.00511
63	0.00828	0.94965	0.00787	0.00591	0.97121	0.00574
64	0.00917	0.94868	0.00870	0.00662	0.97095	0.00643
65	0.00998	0.94770	0.00946	0.00733	0.97072	0.00712
66	0.01106	0.94673	0.01047	0.00806	0.97046	0.00782
67	0.01253	0.94576	0.01185	0.00885	0.97023	0.00858
68	0.01440	0.94673	0.01363	0.00981	0.97023	0.00952
69	0.01641	0.94770	0.01556	0.01097	0.97023	0.01064
70	0.01846	0.94868	0.01752	0.01222	0.97023	0.01185
71	0.02074	0.94965	0.01969	0.01363	0.97023	0.01322
72	0.02330	0.95063	0.02215	0.01522	0.97023	0.01477
73	0.02597	0.95160	0.02471	0.01700	0.97023	0.01649
74	0.02865	0.95258	0.02729	0.01900	0.97023	0.01844
75	0.03179	0.95355	0.03032	0.02127	0.97023	0.02063
76	0.03565	0.95453	0.03403	0.02382	0.97023	0.02311
77	0.04025	0.95551	0.03846	0.02673	0.97023	0.02594
78	0.04555	0.95648	0.04357	0.03010	0.97023	0.02921
79	0.05168	0.95746	0.04948	0.03402	0.97023	0.03301
80	0.05844	0.95844	0.05601	0.03856	0.97023	0.03741
81	0.06564	0.95942	0.06298	0.04369	0.97023	0.04239
82	0.07352	0.96040	0.07061	0.04959	0.97023	0.04812
83	0.08205	0.96236	0.07896	0.05632	0.97220	0.05476
84	0.09112	0.96432	0.08787	0.06374	0.97417	0.06210
85	0.10072	0.96629	0.09732	0.07178	0.97614	0.07007
86	0.11125	0.96826	0.10772	0.08042	0.97812	0.07866
87	0.12287	0.97023	0.11922	0.08975	0.98010	0.08796
88	0.13527	0.97220	0.13151	0.09966	0.98208	0.09788
89	0.14871	0.97417	0.14487	0.11030	0.98406	0.10854
90	0.16406	0.97614	0.16015	0.12176	0.98605	0.12006
91	0.18208	0.97812	0.17810	0.13414	0.98804	0.13254
92	0.20233	0.98010	0.19831	0.14744	0.99003	0.14597
93	0.22322	0.98208	0.21922	0.16188	0.99102	0.16043
94	0.24343	0.98406	0.23955	0.17748	0.99202	0.17606
95	0.26238	0.98605	0.25872	0.19451	0.99301	0.19315
96	0.28031	0.98804	0.27696	0.21307	0.99401	0.21180
97	0.29764	0.99003	0.29467	0.23331	0.99501	0.23215
98	0.31450	0.99102	0.31168	0.25515	0.99600	0.25413
99	0.33111	0.99202	0.32847	0.27891	0.99700	0.27808
100	0.34748	0.99301	0.34505	0.30474	0.99800	0.30414
105	0.50051	0.99800	0.49951	0.49951	0.99900	0.49951
110	0.50000	1.00000	0.50000	0.50000	1.00000	0.50000
115	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
Period Life Expectancy at 65	**18.64**		**18.94**	**21.43**		**21.61**

*When reading the table all values apply to the age in the middle of the one year of age interval. For example, for age 50 the mortality rate and life expectancy applies to someone age 50½ on average.

E. Methodology for the Derivation of Annual Crude Mortality Rates

The main method used to determine annual crude mortality rates was the product-limit estimator method.

Product-Limit Estimator (PLE) Method

With the advent of calculators, and later of computers, methods to estimate crude mortality rates have improved, and the PLE[8] method is such an example. This method produces survival rates from which mortality rates are easily obtained, whereas other methods produce mortality rates by taking ratios of deaths to exposures. The PLE method does not use exposures, but rather considers the product of survival probabilities across ages.

The one-year interval between two consecutive ages is divided into 24 subintervals of half a month each. For each subinterval i, where i = 0, 1, 2,...23, an estimate, $N_x(i)$, is made of the number of people age $(x) + {}^{i}/_{24}$ observed at the beginning of the subinterval, and an estimate, $D_x(i)$, is made of the number of deaths between ages $(x) + {}^{i}/_{24}$ and $(x) + {}^{(i+1)}/_{24}$ observed during the subinterval (i.e. in subinterval i). A survival rate, $p_x(i)$, for the subinterval is then estimated by the ratio of the number of people who survive the subinterval to the number of people observed at the beginning of the subinterval, such that $p_x(i) = (N_x(i)-D_x(i))/N_x(i)$.

The PLE method produces estimators that are more complex to generate and have higher variance, but that are said to be true maximum likelihood estimators (under certain conditions) of crude mortality rates.[9]

The annual crude mortality rates in this study are derived from the PLE method because of its sound statistical basis and the fact that it does not require any particular mortality assumption.

The crude mortality rates for 2010 base Plan year are derived as a weighted average of the annual crude mortality rates observed for each of Plan years 2009, 2010 and 2011. The crude mortality rates for 2010 base calendar year are derived from the annual crude mortality rates observed for year 2010 because of the fact that mortality rates observed for year 2011 are not available as the database contains plan data up to the end of March 2011.

F. Methodology for the Extension of Mortality Rates to Age 120

For this study a modified method to extend mortality rates to age 120 has been used relative to the method that was used present in the recent mortality studies on OAS and CPP beneficiaries. In this study, the form which reflects that mortality at advanced ages increases at an ever slower pace (S-shaped) was obtained by using a 3rd degree polynomial from age 97 to age 120 with constraints to pass through the graduated rates at ages 96 and 97 and at the endpoints at ages 120 and 121. In the recent mortality studies on OAS and CPP beneficiaries a logistic curve approach with an S-shaped behaviour had been used from age 95. The resulting mortality rates at age 120 at the same levels of 700 deaths per thousand for males and 650 deaths per thousand for females that appeared in the recent mortality studies of the OCA.

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8 Also referred to as the Kaplan-Meier Estimator.

9 Broffitt, J. D. 1984. *Maximum Likelihood Alternatives to Actuarial Estimators of Mortality Rates.* Transactions of Society of Actuaries. 36: 77-142.

G. Bibliography

Broffitt, J. D. *Maximum Likelihood Alternatives to Actuarial Estimators of Mortality Rates.* Transactions of Society of Actuaries. 36: 77-142, 1984

Canada. Office of the Superintendent of Financial Institutions. *Actuarial Report on the Pension Plan for the Public Service of Canada as at 31 March 2008*. Ottawa: Office of the Chief Actuary, 2009.

Canada. Office of the Superintendent of Financial Institutions. *Actuarial Report on the Pension Plan for the Public Service of Canada as at 31 March 2011*. Ottawa: Office of the Chief Actuary, 2012.

Canada. Office of the Superintendent of Financial Institutions. *Canada Pension Plan Mortality Study, Actuarial Study No.7*. Ottawa: Office of the Chief Actuary, 2009. Available at: http://www.osfi-bsif.gc.ca/Eng/Docs/cppmrt.pdf

Canada. Office of the Superintendent of Financial Institutions. *Mortality Projections for Social Security Programs in Canada, Actuarial Study No. 12*. Ottawa: Office of the Chief Actuary, 2014. Available at: http://www.osfi-bsif.gc.ca/Eng/oca-bac/as-ea/Pages/mpsspc.aspx

Canada. Office of the Superintendent of Financial Institutions. *Old Age Security Program Mortality Experience, Actuarial Study No. 11*. Ottawa: Office of the Chief Actuary, 2012. Available at: http://www.osfi-bsif.gc.ca/Eng/Docs/oasstd11.pdf

Canada. Office of the Superintendent of Financial Institutions. *Twenty-Fifth Actuarial Report on the Canada Pension Plan as at 31 December 2009*. Ottawa: Office of the Chief Actuary, 2010.

Canadian Institute of Actuaries. *Final Report: Canadian Pensioners' Mortality*. 2014. Available at: http://www.cia-ica.ca/docs/default-source/2014/214013e.pdf?sfvrsn=4

Canadian Institute of Actuaries. *Revised Educational Note: Selection of Mortality Assumptions for Pension Plan Actuarial Valuations*. 2014. Available at: http://www.cia-ica.ca/docs/default-source/2014/214029e.pdf?sfvrsn=0

Office of the Auditor General of Canada. *2014 Spring Report of the Auditor General of Canada*. 2014. Available at: http://www.oag-bvg.gc.ca/internet/English/parl_oag_201405_e_39319.html

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